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SECONDARY IMPACTS OF PUBLIC INVESTMENT IN NATURAL RESOURCES

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FOREWORD

Presented here are proceedings of a symposium on secondary impacts of public resource development held in Washington, D.C., September 25-27, 1968. The symposium was part of a continuing effort to improve measurement of all effects of public programs. Questions are raised increasingly by budget reviewers and program administrators about the total impacts of public investments in natural resources on employment and income levels. The nature of such questions suggests that new methodologies and procedures are needed for evaluating investment alternatives.

The symposium's principal objective was to summarize and evaluate recent experience and current thought on secondary effects of public investments in natural resources. A subsidiary objective was to provide a setting wherein government and university economists might articulate the theoretical and practical issues in measuring secondary effects of resource development. Such interaction should contribute to improved conceptual orientation and procedures for dealing with problems in this area.

The papers encompass social, political, and economic considerations pertinent to evaluation of secondary impacts and to agency procedures and current and potential research techniques. Following the perspective is a review of legislative and administrative documents concerning secondary impacts of resource development. Next is a paper relating economic, political, and social objectives in planning resource development projects. Three papers on theoretical issues in economics assess various orientations to evaluating secondary impacts. Four papers review practices developed by the Appalachian Water Resources Survey, those used by the Bureau of Reclamation, some procedures used by the Soil Conservation Service, and some techniques used in evaluating Resource Conservation and Development projects. Three papers deal with interindustry (input-output) techniques in evaluating secondary impacts, one deals with computer simulation, and one proposes a multistatistical approach to measuring economic growth arising from resource development. The papers were written by staff of the Natural Resource Economics Division or universities cooperating in the Division's research program, with the exception of one by the Deputy Administrator, Economic Research Service, and one by a Corps of Engineers member.

These proceedings exclude many relevant issues pertaining to secondary impacts and treat some issues in an exploratory way. Such inadequacies were partially remedied by the pentetrating questions and comments by the symposium's 150 participants. Although these questions and comments and a closing evaluation of the symposium by Jack L. Knetsch of George Washington University are not available for inclusion in this report, they contributed to fulfilling the symposium's purposes.

In Knetsch's opinion, the symposium gave too little attention to critical appraisals of present agency practices. He was concerned that inadequate knowledge or possible misinterpretation of papers reviewing these practices could result in endorsement of bad economic planning. He noted that little attention was given to the proposition that secondary impacts associated with development activities are generally simply transfers of economic activity from one part of the economy to another and thus cancel out in terms of national efficiency. For so-called secondary benefits to be of legitimate national benefit, special circumstances must be satisfied; e.g., increased efficiency as a result of economies in a region or employment of previously unemployed and immobile resources. Even with such conditions, there is reason to suggest that few of the secondary benefits are in fact national efficiency gains.

Knetsch said that the relevance of other national goals—e.g., income redistribution and balanced regional growth—also cannot be denied. He thought it questionable whether most natural resource development projects contribute significantly to those goals. Lacking much meaningful evidence on the efficiency of such projects to aid in attaining these other goals, the possibility for grossly misallocating resources appears very large.

Burl Back, Morris Weinberger, and Anne Hammill assisted me in planning the program, obtaining authors, evaluating papers, and arranging for the symposium. Gene Wunderlich, Robert Otte, Max Tharp, Ray Johns, and Anthony Grano served as moderators of the various panels and as discussion leaders during the symposium.

Melvin L. Cotner

MELVIN L. COTNER, Director
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PERSPECTIVE

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I have no scholarly insights into either historical aspects of secondary impact measurement or current techniques of such measurement. However, I can perhaps offer some insights on the importance of the subject. As a research administrator, I find myself more often than not in a position between those who might provide some answers—the researchers—and those who need these answers—the program administrators. The former too often do not have the answers. The latter too often seek only that selective measure supportive of a role or program.

I had difficulty putting together a perspective on secondary impacts that would (1) be logical, (2) be relevant to what is to follow, and (3) explain why—considering the somewhat unproductive history of the subject—we can, at this point, assemble such a large group to focus upon and hopefully advance the state of the art.

The best starting point, I expect, is the intense current interest in the subject. A plausible explanation for this interest is our current national focus on social programs to meet the needs of all people, the limited quantity of strategic resources available to meet these needs, and the realization that we cannot deal with these problems only at the macro level. The Employment Act of 1946 was certainly one of our most important steps forward in social programs. But our experience with it has shown that it does not automatically provide equity of income distribution, as some of our colleagues in the late 1940's thought it would.

In short, we are finding that we must specify the subaggregates of the system first so we can determine how the system works and how it can be better directed to serve a greater number of people.

In the most positive sense, we might say that we are seeking to better specify the total impact of programs (or investments) so as to set priorities or predict progress.

THE OTHER SIDE: SECONDARY COSTS

It is my observation that we have devoted much of our research emphasis to the measurement of secondary benefits—in many instances to marginal increments of benefits growing out of investments in traditional resource programs. I have heard many people—some program administrators and some research people—speak glibly of the multiplier effect of programs, always presumed to be positive and significant. But a cursory examination of some of our past program experience would suggest that secondary costs are also an important consideration.

Before enunciating even the first such example, I want to make it clear I am not judging the net effects of any program as having been negative. I only want to point out that secondary costs existed, they were not adequately considered, and the net benefit was less as a consequence of the program's not avoiding or compensating for these costs.

Also, to avoid an appearance of singularly disparaging government programs, I might mention first the private sector and the unplanned industrialization dating back to the previous century which created jobs but at the same time polluted air, water, and land and thus made habitation less desirable and often more costly.

Second, I would mention the mixed Federal-private role in housing. Builders with the security of government financing guarantees have, since the 1930's, sought to meet the primary goal of providing housing units while avoiding the secondary issue of preventing the urban sprawl which now faces our cities as an almost insoluble transit problem.

In agriculture, we have applauded technology and our ability to reduce labor inputs in production, only to be admonished by the Food and Fiber Commission for neglecting the human resources expelled—and raising in the process the real question of whether society achieves any net gain if resources are released but not reemployed.

Likewise, urban renewal and highway programs have been launched to meet primary needs, with only latent discovery of the dislocations they foster for people—as distinct from commerce—or of the ultimate consequence of the type of trends they tend to reinforce or even amplify in land values or population location. (Trying to get anywhere in Los Angeles with or without a car is, I think, sufficient evidence of this type of secondary impact.)

Finally, the argument for considerations of social accounting seems to be built upon the hypothesis that our National Income and Product accounts tend to overstate our national well-being. For example, products are counted as positive contributions with no deduction made for deleterious side effects. A case in point is the production of automobiles being counted as a positive addition to gross national product. However, use of automobiles contributes to air pollution and causes other undesirable side effects. An attempt to evaluate these pluses and minuses in terms of a "net social product" is needed. The U.S. Department of Health, Education, and Welfare is struggling with this task of how we might measure real contributions to well-being.

A MEASURE OF HUMAN WANTS

This leads me to another quandary. Do we really have an adequate concept by which to calculate social costs and benefits? Can we identify the secondary costs and benefits associated with satisfaction of human wants? For example, one might presume that wealth is a legitimate human want. But the utilization of that wealth by one person may be impinged upon by the utilization of wealth by others. For example, we can create the capacity for one man to own a boat, but the impacts of population and of other persons also owning boats result in there being less room in the water for the man to float the boat. Are we reaching a margin of materialism where the wealth norm must be modified or questioned because of the secondary impacts of wealth itself? One could carry this sort of esoteria to the extreme by asking, for example, whether, as we attempt to elevate the poor materialistically, there is room for all this materialism (given its current modes of manifestation). I can't answer this question except to suggest that economics with its conventional norms is not a sufficient discipline for dealing with all the questions before us.

We are confronting such questions of values every day. What is the real role of urbanization in our society now and in the next few decades? Many of our rural resource programs have the limited objective of improving the lot only of those who now live in a given area. Yet we know this country must accommodate another 20 to 30 million people per decade in the years ahead. We also know that much of our progress is urban-born, though we disparage the form and substance of the city. Some would advocate dispersal of population, while others would claim that civilization advances only with urbanization. We don't even have good attitudinal measures on this question, yet almost every land use, water, or development decision is at least marginally related to urbanization.

USE AND CONDUCT OF RESEARCH

A final issue I would like to touch on is the relation of social change to the use and conduct of research. I think we are at a serious juncture in considering the role of research in our society. The systems our social programs are attempting to deal with are so complex that few, even in the research community, understand them. Also, we have never before been confronted with a set of circumstances so demanding of information and counsel. We are dealing not only with absolute values, but also with relative values and aspirations. And we are trying to do things that we have never tried to do before and that we consequently have given little previous attention. This places our traditional approaches to research in a peculiar posture. It makes little sense to attempt to extrapolate nonexistent historical observations through trend analysis and projection, no matter how sophisticated the mathematics.

I would suggest two implications for research:

1. Implementation of new programs offers the possibility for social experimentation. This casts the researcher in the role of an evaluator with an integral role in program direction. It also has some program and political implications. Our biggest problem may be whether our prevailing political mores can adjust to an experimental program orientation after some decades of dogmatic posture. This, only time will tell.

2. As our social systems become more complex, communications will become more of a problem for researchers. How do we communicate all of the if's, but's, and coefficients of increasingly complex systems? As Kenneth Clark puts it:

> Real progress comes, a community [is] enriched and a civilization [is] given depth and substance, when some human beings refuse to settle for mere form and what has been. They insist upon more from themselves. They insist that the created human environment, our cities, reflect a respect for that which is human in man. Initially, such persons are vague and abstract. They talk of values, esthetics and ethics, thereby irritating the practical men of affairs who above all are direct, coherent and concrete with little patience for fuzzy and softminded theorists.[1]

Clark has eloquently and poetically stated the problem. Governor Breathitt states the challenge:

> A characteristic of our focal problems is that their solution requires the involvement of not only the exercise of interdisciplinary technical expertise, but it also requires the direct involvement of the lay citizen. The citizen who is suffering most from the problem is quite often least able to understand or to accept the technical solution which is indicated. It is important, therefore, that the technician develop not the optimum technical solution, but rather the solution which can successfully be accommodated to the processes of existing institutions and to the capacity for acceptance of all people involved. This requires technical personnel to work at all levels of the program so that program decisions are based upon the best alternatives that our technology could contrive.[2]

I think these two quotations focus on what is becoming a serious problem to professional social scientists. We deal in a body of knowledge that is not durable or absolute. Thus, I conclude that at least half of our job is communication and, further, that we have been doing less than an adequate job. As a somewhat harrassed research administrator recently remarked: "We can no longer plead sanctity as a basis for research budgets." I would suggest that instead of talking to ourselves under the "publish or perish" admonition, we must start to, in the jargon of the sociologist, "relate." Who else but an economist can explain what an economist is talking about? We still need so-called basic research; we need to understand whatever we can about human motive and human reaction, particularly as such knowledge can be generalized to a variety of problems. But increasingly we must become involved in the application of this knowledge since trained social scientists can probably best understand it and avoid or recognize its misuse. We must interpret and we must be patient, rather than overly critical, when we are misinterpreted.

[1] Clark, Kenneth, "Cities for Men—Man's Hope for Richness of Real Community," lecture given at symposium sponsored by the U.S. Dept. Agr. Graduate School and published in Providing Quality Environment in Our Communities, Graduate School Press, U.S. Dept. Agr., 1968.

[2] Breathitt, Edward T., former Governor of Kentucky, in an unpublished address entitled "A Program to Stimulate Area Development in the United States."

CONCEPTS AND OBJECTIVES UNDERLYING THE EVALUATION OF SECONDARY EFFECTS

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Government as an integral part of society is a means through which the goals of society are achieved. This concept is set forth by the Office of Career Development of the U. S. Civil Service Commission in describing the role of its Centers in Executive Development. [1] The Office also states that executive development is directed toward broadening understanding and acceptance of the functions of other groups within the organization and related government entities. The subject of this workshop is not far afield from this thesis.

Current efforts in the evaluation of secondary impacts of natural resource development stem in part from society's changing goals and consequent changes in government's legislative and administrative programs. Economists employed by the government, as well as other public servants, respond to society's changing value systems, political issues, and legislative goals. Secondary impacts may increase employment and income, redistribute income, reduce welfare payments, or enhance environmental quality. We are interested in these effects because they are desired by society and because agencies within the government have responsibilities for helping society achieve its goals.

Efforts within the economics profession are being reoriented to provide assistance in furthering these public goals. Involved in this change is greater emphasis on economic structure, interindustry and interregional relations, and distribution of income, both functionally and personally. There is the growing realization that to objectively evaluate effects of public investment on employment, income, purchasing power, and production, it is necessary to broaden our inquiry to cover those economic activities that result from the initial project effects. Our interest in secondary benefits derives from this situation. It is important to emphasize, however, that evaluation of secondary benefits has little practical value in the formulation of public investment plans unless one includes among the purposes of investment increased employment, economic development, or some degree and kind of income redistribution.

In this paper, I will attempt to provide a general background for the following papers which examine in considerable detail the theoretical and quantitative aspects of secondary effects from the point of view of public administration, sociology, and economics. First, however, I will discuss briefly some of the relevant legislation and administrative guidelines in an effort to depict the evolution of the evaluation problems associated with secondary benefits.

LEGISLATION

The Employment Act of 1946 (P.L. 304) may be a legislative starting point in the serious formulation of public programs for economic development. Its stated purposes were the preservation of employment, production, and purchasing power. The Public Works and Economic Development Act of 1965 (P.L. 89-136) expands on these objectives and public values. It refers directly to such ideas as maintenance of the national economy at a high level, increased employment opportunities, the waste of human resources through unemployment and underemployment, and the resultant hardships to individuals and their families. This act concludes that the Federal Government should cooperate with the States to help areas and regions of substantial and persistent unemployment and underemployment. Of course, these pieces of legislation were preceded by the many public works programs of the 1930's to alleviate the problems created by the depression.[2]

[1] Office of Career Development, brochure describing its 1967-68 Seminars for Executive Development at Kings Point, N. Y., and Berkeley, Calif., U.S. Civil Serv. Commission.

[2] One might call to mind that even before the depression, Federal programs for economic development were instigated through legislation such as the Homestead Act and the Reclamation Act of 1902. However, these programs for economic development perhaps were motivated more by Jeffersonian agrarianism and "land-hunger" among immigrants than by present day values of technology, economic efficiency, and human welfare.

Many pieces of Federal legislation deal directly with conservation and development of natural resources, but I shall refer only to a few that in my estimation are pertinent to the evolution of the concept of "secondary benefits." These are the Reclamation Act of 1902, the Flood Control Act of 1936, the Watershed Protection and Flood Prevention Act, Section 102 of the Food and Agriculture Act of 1962, and the Appalachian Regional Development Act of 1965.

The Reclamation Act of 1902

This act provided authority for the Secretary of the Interior to advance the cost of constructing projects to make irrigation water available to lands in the arid and semiarid regions of the West. Under succeeding amendments to the Act and as presently administered, the Reclamation Program has brought to irrigation water users two major sources of financial assistance; namely interest-free Federal Financing and the use of revenue from hydroelectric power and municipal water to meet part of the costs allocated to irrigation.[3] Clyde Stewart, in his paper prepared for this meeting, states that these financial aids to irrigation are regarded by the Bureau of Reclamation to be in recognition of widespread benefits from irrigation development. It is of significance to this workshop that the evaluation of secondary benefits and their application in establishing project justification were first employed in administering the reclamation program. As noted later, in this paper and in others written for this workshop, this situation contributed to lengthy discussions among agency representatives in their efforts to establish uniform practices for economic analysis of water resource projects and programs.

The Flood Control Act of 1936

The Flood Control Act of 1936 had a strong influence, although somewhat delayed, on agencies' recognition of secondary benefits from water resource development projects. In the Act's statement of policy, two declarations in particular were significant: (1) Improvements of rivers and other waterways for flood control purposes are in the interest of the general welfare, and (2) the Federal Government should improve navigable waters for flood control purposes if the benefits "to whomsoever they may accrue" are in excess of the estimated costs.

[3] A more complete account of the reclamation laws, regulations, and policies pertaining to limitations on Federal irrigation projects is given in a 1964 Committee Print, "Acreage Limitation Policy," prepared by the U.S. Department of the Interior pursuant to a Resolution of the Committee on Interior and Insular Affairs, U.S. Senate.

For many years, under authority of the Act, the U. S. Department of Agriculture and the U. S. Army's Corps of Engineers did not evaluate secondary benefits for project justification. Perhaps recognition of the legislation as a single-purpose Act for "flood control" held back the pursuit of other objectives, whose attainment may be dependent upon secondary effects. Another factor might have been that the 1936 Flood Control Act contained no provisions for formal cooperation by non-Federal agencies in the selection of projects or in the planning of works of improvement.

The Act authorized flood control surveys by the Department of Agriculture in more than 1,000 watersheds. However, the Congress in subsequent legislation approved only 11 watersheds for operation.[4] Although the Congress in the 1944 Flood Control Act expressed its policy "to facilitate the consideration of projects on a basis of comprehensive and coordinated developments," little was accomplished in this direction until passage of the Water Resources Planning Act in 1965.

The Watershed Protection and Flood Prevention Act

As a forerunner to enactment of this law (P.L. 566), a pilot watershed program was authorized by the Congress in the Department of Agriculture Appropriation Act of 1954. This program, in contrast to

[4] Flood Control Act of 1944 (58 Stat. 887). In contrast to watersheds authorized in succeeding legislation, those authorized in this legislation were larger; in fact, they contained groups of subwatersheds which would under P.L. 566 be placed in separate projects.

In accordance with parliamentary reference procedure of the Congress, the Department's flood control reports were transmitted to the Public Works Committees for their consideration. A 1952 report (House Committee Print No. 22, 82nd Cong., 2d Sess.) of a subcommittee designated by the Committee on Public Works, House of Representatives, recommended "that legislation be enacted to cancel present directives and authority for the Department of Agriculture to make flood control surveys presently authorized under flood control law or resolutions of the Committee on Public Works." Two years later, Sec. 7 of the Watershed Protection and Flood Prevention Act (P.L. 566) repealed the provisions of the 1936 Flood Control Act pertaining to the Department of Agriculture. This act also provided for congressional approval of projects by the Committee on Agriculture and Forestry of the Senate and the Committee on Agriculture of the House of Representatives. Authority for prosecution of works of improvement in the 11 projects authorized in the 1944 Flood Control Act, however, was not affected.

the flood control program, had as its basic authority the Soil Conservation Act of 1935 (P.L. 46). The program was intended to demonstrate the feasibility of local-Federal cooperation and to accumulate experience on the physical results of watershed measures to guide future flood prevention activities. The pilot program, consisting of 65 small watersheds, was to be completed in 5 years. However, long before its completion, P.L. 566 was passed without full benefit of the demonstration.

The Watershed Protection and Flood Prevention Act and its legislative history emphasize "grass roots" planning and the formulation of programs to meet local objectives and desires. Although it is not recognized by all, watershed projects are planned by local groups with Federal assistance—in contrast to federally planned projects under the basic authority of the Flood Control Act of 1936. Policies and procedures developed by the Soil Conservation Service attest to the importance of the role of non-Federal groups in administering the program.[5] When passed in 1954, P.L. 566 was concerned primarily with works of improvement for flood prevention and agricultural phases of the conservation, development, utilization, and disposal of water. Subsequent amendments and administrative policy have enlarged upon the multipurpose character of the program by authorizing technical and financial assistance for other purposes, including recreation, fish and wildlife enhancement, municipal water supply, and employment of underutilized labor and other resources. Legislation is currently being considered by the Congress to add water quality improvement to this list. The watershed program calling for multipurposes of development, local plan formulation, and consideration of both national and local objectives and desires poses a complex problem to economic analysts concerned with identifying secondary consequences and benefits. This problem takes on special importance in view of national guides for economic analysis developed by interdepartmental efforts.

The Food and Agriculture Act of 1962

This act (P.L. 87-703) provided for the Secretary of Agriculture to aid local public agencies, sponsors, and associations in carrying out Resource Conservation and Development (RC&D) projects. Such projects would accelerate programs of conservation, development, and use of all land, water, and related resources within a resource area where such acceleration would provide additional economic opportunities to local people.[6] As is true of the watershed protection and flood prevention program, RC&D projects are locally initiated and sponsored. The RC&D program, however, is explicit in its purpose of creating additional economic opportunities. Evaluation of secondary benefits under the concept of national economic efficiency poses problems here as well as with other programs where local objectives may be uppermost or—at the least—are to be reconciled with national and regional interests. It may seem that establishment of priority of aims would be required.

The Appalachian Regional Development Act of 1965

P.L. 89-4 has focused further attention on attainment of employment, income, and economic development goals via natural resource conservation and development. The cited purpose of the Act was "to provide public works and economic development programs and the planning and coordination needed to assist in development of the Appalachian region." Further elaboration of this purpose discloses several program characteristics having particular relevance for economic evaluation. Such characteristics include regionwide development, basic facilities essential to growth and regional productivity, and encouragement of private investment. The Appalachian Act provides for a group of programs, including water resource development, development of a highway system, demonstration health facilities, land stabilization, conservation and erosion control, timber development organizations, and mining area restoration. Existing programs such as the following are authorized for supplementation and modification: Vocational education facilities, sewage treatment works, housing, and Federal grant-in-aid programs. The multiprogram aspect of this effort in regional development has significant implications for economic evaluation of secondary impacts.

This regional program of resource development creates difficulties in applying conventional economic theory to evaluation.[7] The concept of net secondary

[5] Soil Conservation Service, Watershed Protection Handbook, U.S. Dept. Agr., Aug. 1967.

[6] From descriptive summary of the Food and Agriculture Act of 1962, U.S. Dept. Agr., Sept. 1962.

[7] Harrison, Robert, "The Role of Secondary Effects in Project Formulation Justification and Evaluation for the Appalachian Water Resources Survey," prepared for this symposium.

benefits may not be wholly relevant to the Appalachian program, since costs of the secondary activities also increase employment, income, production, and purchasing power. When attained in depressed regions such as Appalachia, gross secondary benefits may be more pertinent to the policy of authorizing legislation. Methodologically, however, economists are confronted with the problem of evaluating the effects of these changes in costs and incomes on other regions. Little is gained, other than redistribution, if the gains of one region are offset by losses in another. If the Appalachian region gains some economic activity at the expense of another region, what by way of new activity occurs in the other region? What may be the timelag in such activities if they do occur? Our present knowledge of economic growth appears to be inadequate for the task of explaining the impacts of increased demand (say in Appalachia) on production of known goods and services, and the development of new ones in other regions. Perhaps historical research on the economic development of the Nation as it expanded westward would provide some guides to this question and to our present planning methods.

ADMINISTRATIVE GUIDELINES TO EVALUATION OF SECONDARY BENEFITS

In any prolonged discussion of policies, practices, and procedures for economic analysis of water resource development, reference is sooner or later made to several documents. Almost in order of probability they are (1) the "Green Book," (2) Circular A-47, and (3) Senate Document No. 97.

The "Green Book"

When Federal agencies organized the Federal Interagency River Basin Committee (FIARBC) in the 1940's, a subcommittee on benefits and costs was established for the purpose of formulating mutually acceptable principles and procedures for determining benefits and costs of water resources projects. The subcommittee's first substantial report, Proposed Practices for Economic Analysis of River Basin Projects, was published in May 1950. Known as the "Green Book," it was reissued with only minor revisions in May 1958.[8] At that time, the Green Book was adopted by the Interagency Committee on Water Resources (successor to the FIARBC) as a basis for consideration by the participating agencies. It never became a statement of mutually accepted principles and procedures. In particular, consideration of secondary benefits was one of the points of issue. The Department of Agriculture was silent on this question, but the Corps of Engineers thought "it would be preferable if the discussion of secondary benefits were to bring out more clearly that from a national public viewpoint secondary benefits will be applicable in project evaluation only under unusual circumstances." The U.S. Department of the Interior indicated its concern with "tangible expression of benefits from the provision of settlement opportunities, assistance in the development of undeveloped regions, stabilization of existing developments; recognition of the many project effects accruing outside the immediate project area; and the importance of regional viewpoint as well as national viewpoint."

The Green Book defined secondary benefits as "the values added over and above the value of the immediate products or services of the project as a result of activities stemming from or induced by the project. In the cited example (irrigation), the value of the bread over and above the value of the wheat content would be a secondary benefit."

It followed that a definition of secondary costs was also necessary. Again from the Green Book: "Secondary costs are the value of goods and services which are used as a result of the project (other than those covered by project and associated costs). These include the costs of further processing of the immediate products or services of the project and any other costs, over and above project and associated costs stemming from or induced by the project. In the irrigation project example, the costs of transporting the wheat, elevator and milling costs, baking costs, and the costs of distribution to consumers would be secondary costs."

In measuring net secondary benefits, all secondary costs were deductible. Also, such benefits were not considered attributable to the project under evaluation if similar benefits would occur in absence of the project. Until recently, all agencies except the Bureau of Reclamation generally concluded that the latter situation would exist, and did not claim secondary benefits. In other words, from a national viewpoint it was assumed that sufficient offsets would occur through the economy to nullify the project's claim to secondary benefits.

[8] Subcommittee on Benefits and Costs, Proposed Practices for Economic Analysis of River Basin Projects, Report to the Interagency Committee on Water Resources, prepared by the Subcommittee on Evaluation Standards, May 1958.

The Green Book recognized the concept of alternative use-value of the goods and services diverted into project uses. Absence of such alternatives was considered to be the exception. As a generalization, full employment of resources was basic to the recommended evaluation principles and procedures. Perhaps this idea accounts in part for the position then taken in reference to secondary benefits. The Green Book suggested that conventional economic evaluation rests primarily on a national viewpoint—but it defined the national viewpoint in an economic context, just in terms of national income. The point I wish to make is that the legislative mandate and the theory of the economics discipline involved seem to be incompatible. Karl Polanyi reports dramatically on this situation when he discusses the change from regulated to self-regulated markets at the end of the 18th century as being a complete transformation in the structure of society.[9/] The structure and the will of society today seem to be calling for a reappraisal of economic theory and its revision to accommodate the value system made manifest by government.

Circular A–47

A 1943 Executive Order (9384) required all agencies to submit their reports on public works and improvement projects to the Bureau of the Budget for comments and to include these comments on specific projects when submitting reports to the Congress. As these reviews proceeded, it became apparent that the several agencies were using different standards and procedures in evaluating benefits and costs of their water resource projects. In an attempt to improve matters, the Bureau issued Circular A-47 on December 31, 1952.[10/] The Congress repeatedly clashed with the Bureau of the Budget due to the restrictions imposed by the circular on the Federal agencies in program development.[11/] In part because of the adverse congressional reaction, the Bureau of the Budget, working with the Federal agencies (primarily through the Interagency Committee on Water Resources), redrafted the circular in 1954 in an effort to reach more acceptable standards and procedures; however, the new version was never released officially. The issues were not resolved until several years later when Senate Document 97 was issued.

Although A-47 created many problems for Federal agencies, it did promote acceptance of several principles of project formulation and evaluation currently recognized by the resource planning "establishment." One such principle relevant to our workshop was incorporated in the instruction to include the following information in evaluation reports: "A description of the need for the production or services which would result from the program or project; the relation of the program or project to the other elements of the resource development program of the region in which the program or project is to be undertaken; the contribution of the program or project to balanced national conservation and development; and the efficiency of the program or project in meeting regional or national needs."

At that time, I think that neither the Bureau nor the agencies envisioned that in a few years we would be making use of electronically computed programs to provide a cardinal measurement of the information requested.

On secondary benefits, specifically, Circular A-47 instructed that such benefits attributed to projects be estimated and shown separately from primary benefits. It also stated that "until standards and procedures for measuring secondary benefits are approved by the Bureau of the Budget, the evaluation shall be based mainly upon primary benefits."

Senate Document No. 97

SD 97 replaced Circular A-47 in prescribing policies, standards, and procedures for formulating, evaluating, and reviewing plans for water resource and related land resource projects. The document was initiated through the request of President Kennedy, October 6, 1961, when he appointed the Secretaries of the Army; Interior; Agriculture; and Health, Education, and Welfare to review existing principles, standards, and procedures and to make appropriate recommendations. This selection of Cabinet members for the assignment was significant since they would comprise the Water Resources Council for which legislation was then being considered. The Water Resources Council, established in 1965, has accepted Senate Document 97 as an interim guide only.

[9/] Polanyi, Karl, The Great Transformation, the Political and Economic Origins of Our Times, Ch. 6, Beacon Press, Boston, 1968 (9th print.).

[10/] Budget Bureau Circular No. A-47, "Reports and budget estimates relating to Federal programs and projects for conservation, development, or use of water and related land resources," Dec. 31, 1952.

[11/] Congressional Quarterly Fact Sheet on Water Resources, June 6, 1962.

As indicated earlier, Senate Document 97 was a liberalizing force in the planning of water resource projects. With respect to secondary benefits, the document permits planning reports to indicate expected secondary benefits attributable to the project from a regional, State, or local viewpoint. It further requires planners to evaluate such benefits, when this procedure is considered pertinent, and to compute an additional benefit-cost ratio. Also of inferential importance to the secondary benefits issue is the inclusion of "the well-being of people" as one of the explicit objectives of planning the best use of water and related land resources. In connection with attaining this objective, secondary benefits take on a different meaning than heretofore accepted.

Several other standards for formulation and evaluation of plans set forth in Senate Document 97 relate to the evaluation of secondary benefits. I shall touch upon only a few of the highlights here, as other papers in this workshop elaborate more fully upon the subject. In areas designated under the Area Redevelopment Act of 1961 (75 Stat. 47), evaluation standards permit including as benefits of a project the value of the labor and other resources used to the extent that they would in absence of the project be unutilized or underutilized. Such benefits are identified as "redevelopment" benefits. The general setting and viewpoint for planning requires among other things that evaluation of project effects shall reflect "consideration of all effects, beneficial and adverse, short range and long range, tangible and intangible, that may be expected to accrue to all persons and groups within the zone of influence of the proposed resource use or development." This is a large order!

EMERGING STATUS OF SECONDARY BENEFIT EVALUATION

In a recent address to the Second Annual Conference of State and Federal Water Officials, John Baker, Assistant Secretary of Agriculture, made a plea for identification and evaluation of all the benefits of a project and for including each as an integral part of the benefit cost analysis.* In urging that greater attention be given to evaluating all benefits, he sought inclusion of such results as better geographic balance of economic opportunity, elimination of poverty, improved water quality, and improvement of other elements of the total environment. It is significant to the changing role of planning that Baker also recognized that comprehensive water and related land resource planning should be guided by comprehensive overall area planning.

It seems obvious to me that secondary benefits are of importance in formulating investment plans only because of explicit value judgments about desired ends. Such judgments are developed largely outside the realm of economics. Perhaps if selected value judgments were defined as tentative public goals, their attainment could be pursued through economic appraisal of alternative means. Investments in many economic and social activities other than in natural resources could be brought to bear on the stated goals. If such were the case, far less attention would be given to evaluation of secondary benefits stemming from or induced by natural resource projects.

*Ed. Note: Speech by John A. Baker, formerly Assistant Secretary, U.S. Dept. Agr., presented at the Second Annual Conference of State and Federal Water Officials, Detroit, July 9, 1968.

RELATING ECONOMIC EVALUATION OF FEDERAL RESOURCES PROGRAMS TO POLITICAL OBJECTIVES AND SOCIAL VALUES

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> Economics is the study of how man and society choose, with or without the use of money, to employ scarce productive resources, which could have alternative uses, to produce various commodities over time and distribute them for consumption, now and in the future, among various people and groups in society.[1]

Broadly defined, there are no conflicting optimum sets of political and economic decisions for given resource allocation situations. The problem is that economic analyses are usually restricted in their scope and often relevant political and social factors are not considered.

The purpose of this paper is to consider major political objectives and social values relevant to Federal natural resources programs, to examine the role of the economist in contributing to improved political decision-making, and to suggest promising areas for improvements in analytical contributions.

First, there is a brief review of the economic rationale for public intervention into the operations of the production, consumption, and exchange systems of the "private" sectors of the economy. Following is a short review of current benefit-cost practice, with emphasis on the basic rationale, the underlying assumptions, and the distinct value judgments entailed.

In the second section, provision of economic information as a basis for political decision-making is discussed. The major objectives of Federal resources programs are explored. Performance of current planning efforts in including these objectives is discussed. And recent literature proposing reforms is briefly reviewed and evaluated.

In the third section, possible promising areas for additional analytical efforts are highlighted and a revised strategy for the employment of analytical resources is suggested.

EFFICIENCY, GOVERNMENT INTERVENTION, AND BENEFIT-COST ANALYSIS

Economic Efficiency

The economic logic of the competitive market economy is based on freedom of choice and the self-interest of consumers and producers. In theory, the consumer chooses in the market, from all possibilities, the pattern of goods and services that maximizes his satisfaction. The producer, responding to market prices, selects the combination of resources that will ensure maximum net returns from his production. The unrestricted price system functions to equate marginal utilities and marginal costs. The resulting pattern of production and consumption defines the condition of economic efficiency; the satisfaction of each consumer is maximized subject to his income constraint. Efficiency defines the selection of the best possible pattern of resource allocation for obtaining desired results within relevant constraints.

The conceptual simplicity of the competitive market allocation system and its magnificent performance in many sectors have induced widespread acceptance of the system, particularly in Western countries. But, in spite of this support, the system has never been permitted to operate completely unhampered. There are historical reasons for this. However, let us focus our attention on economic

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[1] Samuelson, Paul A., Economics, An Introductory Analysis, 7th ed., 1967.

rationale. Why has society, through government or other collective action, intervened in the allocation of resources through the private market system?[2]

Economic Rationale for Public Intervention

Economic arguments for public intervention are generally related to conditions of consumption or production, the planning period, or income distribution.

Conditions of Consumption

In the usual market transaction, the price the buyer is willing to pay measures the value of the marginal unit of the commodity to him. Since other buyers cannot ordinarily consume or use the same units of the commodity, the price also measures the full value of the commodity to society. Two important cases diverge from this situation—collective goods and goods characterized by external economies or diseconomies of consumption. In both cases, the market price, if one exists, does not reflect the full value of the commodity to society.

A collective good is a commodity made available without a user charge, either because to assess a charge on each occasion would be excessively cumbersome or because use is not voluntary or even clearly definable. It is not feasible to assess people each time they breathe clean air, nor can they be "excluded" by pricing mechanisms from the enjoyment of it, if it is present.

Usually collective goods cannot be provided by private firms because such goods do not induce a profitable flow of income to the producer. The important feature of collective goods is that there are no market prices to assist in appraising their value.

Collective goods are often associated with external economies of consumption. In this case, the act of consumption creates a collective good. When a man is vaccinated for smallpox, the immunity received is only a part of the social value, as everyone in contact benefits from the reduced danger of infection. Thus, for this class of economic goods, the consumer is not the sole beneficiary and the amount he is willing to pay does not measure the entire value to society. It may be socially desirable to provide the goods even though the amounts collectable from direct users do not cover production costs. In these cases, market prices are not appropriate measures of social value.

Conditions of Production

Collective intervention on the production side of the market is generally based on the presence of potential economies of scale, restricted competition between producers, or external effects. Some activities can be performed economically only on such a large scale that it is infeasible for competitive enterprises to assemble the required risk capital or the necessary management capability. Water and power systems and navigation projects have sometimes been developed as collective enterprises to control monopolistic pricing. Alternatively, private utilities have been unable to collect for the extra-market flood control services provided by their power projects.

Planning Period

It has been demonstrated or supposed that private investors will take an unduly short view of the consequences of their investments. This seems particularly important in considering unique natural attractions and long-term investments such as large reservoirs or, possibly, timber production. Short time horizons result in high discount rates. Thus, the argument is that the private market may undervalue certain natural resources that could yield substantial social values over time.

Income Distribution

The distribution of income resulting from equilibrating exchange systems may be socially unacceptable. There are concerns about minimum standards for a decent living for the poor and possible excesses of wealth among the rich. Note that the terms "decent" and "excesses" could be translated into levels of consumption. But in doing so some of the implied social values such as "status" or "discretionary power" may be lost.

There are two implications of the income distribution issue. The first is that government may intervene to deliberately redistribute income; for

[2] Even Adam Smith, the most prominent proponent of free choice and the private market, felt that government intervention was desirable in certain areas. Subsequent proponents have often found it either desirable or convenient to oppose or assume away all government intervention. See discussion by George L. Stigler, "The Economist and the State." American Economic Review, Vol. LV, No. 1, Mar. 1965, pp. 1-18.

example, through unemployment compensation, social security, and welfare payments. The second is that the poor may enter the market with "too little" income and the rich with "too much," distorting the patterns of demand and resulting in a set of prices that are not equivalent to the prevailing social values. For example, market prices may signal the production of "too many" trips to Europe or "too little" high-protein baby food.

The foregoing discussion has reviewed the dominant economic rationale for government intervention and alluded to various situations where the prices in the private market may not be accurate measures of the social values involved.[3] We shall now briefly review the approach and assumptions of current benefit-cost practice.

Benefit-Cost Practice: Assumptions and Value Judgments

In benefit-cost practice, the central objective is generally limited to increasing national income from the project or projects under consideration. The approach is to compare benefits and costs "to whomsoever they may accrue" with and without the project, or plan, under analysis. Benefits and cost are expressed in monetary terms based on actual or simulated prices for goods and services.

The economic rationale for the use of market prices assumes that the inputs and outputs of the project can be valued by their opportunity costs in the market. The market prices are assumed to result from freely competitive adjustments in demands and supplies and to be at or near equilibrium under full employment conditions. It is further assumed that neither commitments of inputs to the project nor production resulting from the project will significantly alter prevailing market prices; that is, the project is insignificant in terms of its impact on the market prices prevailing. Thus, the analyst assumes insignificant effects on a freely competitive economy at static equilibrium.

[3] Robert Dorfman, in a similar review of the economic rationale for public intervention, observes that benefit-cost analysis has had its highest development in the field of water resources because of the production of salable commodities–water and power–bearing market prices. This is not true, of course, for the services produced; that is, flood control, recreation, navigation, and fish and wildlife protection. See "Introduction," Measuring Benefits of Government Investments, Robert Dorfman, ed., The Brookings Institution, Wash., D.C., 1965, p. 8.

This economic rationale is based on a political theory of a free society. The economy serves to distribute production to each individual's preferences as revealed and rationally pursued with his disposable income in the market place. The consumer is sovereign. It follows that it is inappropriate for the analyst or others to make alternative judgments of value.[4] Such judgments could disturb the static equilibrium of the market and result in an "inefficient" allocation of resources.

One powerful value judgment implicit in this line of reasoning, however, is that the current distribution of income is optimal. Alternative income distributions would lead to different market prices. However, government programs inevitably have impacts on distributions of income. Projects of different size, location, and composition will transfer income in different amounts to different people in different time periods.

Income distribution, employment, and other secondary project effects do not enter into the analysis of projects but are important to the Congress. Thus, in practice, judgments of effects other than national income gains are "added on" to the analysis during reviews in the executive branch and in the deliberations of the Congress. Since these subsequent judgments are based on relatively little additional analytical information, it must be assumed that such judgments are not as sound as they might be if information were improved.

ECONOMIC ANALYSIS FOR POLITICAL DECISIONS

The purpose of economic analysis of natural resources programs, in general terms, is to provide economic information. This information is to be a basis for political decisions resulting in efficient allocations of resources by the public sector in its interaction with the nonpublic sector of the economy. An efficient pattern of allocations depends upon the objectives of society.

It seems rather obvious that benefit-cost practice has proved to have some theoretical and practical deficiencies in providing the kind of information needed for decision-making on resources programs at the

[4] See discussion by Aaron Wildavsky, "The Political Economy of Efficiency: Cost-Benefit Analysis, Systems Analysis and Program Budgeting," Public Administration Review, Dec. 1966, pp. 292-310.

national level. It may be helpful to try to characterize in general terms the political environment within which critical decisions on natural resources programs are made.

The Political Economy of Federal Resources Programs

The very idea of characterizing a political decision-making environment should be considered somewhat audacious. De Jouvenal, a prominent political philosopher, has stated, "The basic condition of all political science is to see power, as it were, stereoscopically from both angles. The very possibility of such a science is, in truth, open to doubt."[5] In line with this counsel, the aim is therefore limited to sensitizing in the would-be analyst an awareness of his ignorance of the political economy; a curiosity as to the real bases of the criticism of his analyses; and a healthy agnostic attitude toward the analytical procedures he is applying.

The basic political criterion for judging program effectiveness is the program's effect on political power. In democratic societies especially, this power comes from public support in the short run. If such support is lacking, the politician will enter the expected losses of political power into his analysis of the proposed program or project. Unpopular decisions are made, but they must either be defensible in socially acceptable terms or be balanced by programs or projects that enhance popular support and political power.

Multiple Objectives of Natural Resources Programs

Federal natural resources programs are carried out to achieve a variety of objectives. These may include (1) economic development with a spacial allocation of growth that conforms to national growth objectives, (2) equity in the distribution of incomes among regions and groups, (3) social welfare incorporating provision of necessities or natural environmental amenities at satisfactory levels, and (4) national security improving national military and diplomatic strength and insuring domestic tranquility.[6] The choice or mix of Federal programs is also shaped by the assumed potential or demonstrated ability of the Federal bureaucratic structure, with its particular set of incentives, to carry them out effectively.[7]

The relative importance of these goals and the significance of their complementary and competitive relationships vary with the basic structure of underlying political power and, in turn, the social values that determine public acceptability in the various political constituencies. The specification of the relevant objectives, their relative importance, and the translation into quantified goals to be achieved is always uncertain. The politician might suffer a crippling loss of flexibility and therefore power if he were committed in advance of final decisions. Furthermore, he lacks information on the gains and losses relevant for different program objectives and their political acceptability often up to the final "moment of truth." This is a major reason why the analyst will never get a definitive answer to his question, "What do they really want to do?"

Decentralized Control and Fragmented Decision-Making

Natural resources programs often involve Federal, State, and local levels of government, special districts, citizens' groups, private firms, and consumers of resource goods and services. The patterns of production, consumption, exchange prices, and income distribution resulting from the initial Federal "intervention" usually cannot be forecast with reliable accuracy, since central control is lacking. The presence of a decentralized system of decision-making means that all significant changes in public policy are uncertain. The outcomes of the actions taken may not attain quantified goals and may in fact be in the opposite direction from anticipations.

A "New Economics" of Resources?--Proposed Reforms

Recently, a number of articles have criticized current benefit-cost procedures and presented proposed reforms in the analysis of public investments. Maass proposes that the executive departments prepare data showing the effects of alternative trade-offs between the net national income benefits and, for example, income distribution benefits. These data would be submitted for

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[5] De Jouvenal, Bertrand, On Power: It's Nature and the History of It's Growth, Beacon Press, Boston, 1962, p. 283.

[6] See Berry, Brian J. L., Strategies, Models and Economic Theories of Development in Rural Regions, Agr. Econ. Rept. No. 127, U.S. Dept. Agr., Econ. Res. Serv., Dec. 1967, p. 36.

[7] See Wilson, James Q., "The Bureaucracy Problem," The Public Interest, No. 6, Winter 1967, pp. 3-9.

selection of one ratio as a planning standard by the Congress. This proposal would no doubt generate debate on objectives which would be illuminating to both the Congress and the executive branch, but such a decision on a fixed trade-off ratio would seem to become increasingly arbitrary over time if, in fact, it was appropriate for all the relevant project conditions at the time of decision. Nevertheless, the proposal that additional information on alternative objectives be presented with development plans for congressional decisions is certainly appropriate.[8]

Other writers have been concerned with the frustrations of adequately considering the environmental quality benefits in current evaluation procedures. Wollman has proposed a "new economics of resources." [9] He indicts the current economic analysis for its inability to adequately consider third party, or nonmarket, effects. And he spotlights the prevalent irreversibility of environmental deteriorations and the limitations of consumer sovereignty when the consumer is ignorant or incapable of grasping technical complexities resulting from his actions or affecting his welfare. These conditions result in the probable bias against appropriate consideration of losses suffered or benefits realized from environmental deterioration or improvement. The conclusion emerges that an active, informed, sensitive minority must be granted extraordinary powers to act immediately, pending development of adequate information and general public support.

The policy implications in particular of this and similar statements are vigorously attacked by Wildavsky. [10] He views the "new economics" as not economics but a loosely fashioned rationale to support political action by an active minority, action which is inconsistent with our political traditions.

[8] Maass, Arthur, "Benefit-Cost Analysis: Its Relevance to Public Investment Decision," Quarterly Journal of Economics, Vol. LXXX, May 1966, pp. 208-226. Maass uses the term efficiency benefits for national income gains. I prefer to reserve the term efficiency to identify optimum patterns of resource allocations for achieving specified goals.

[9] Wollman, Nathaniel, "The New Economics of Resources," Daedalus, Fall 1967, Proceedings of the American Academy of Arts and Sciences, Vol. 96, No. 4, pp. 1099-1114.

[10] Wildavsky, Aaron, "Aesthetic Power or the Triumph of the Sensitive Minority Over the Vulgar Mass: A Political Analysis of the New Economics," Daedalus, Vol. 96, No. 4, pp. 1115-1128.

One very interesting point emphasized by Wildavsky is the general inertia of present public support for environmental quality programs, as was true in the past with other conservation programs. He observes that mass support may be generated for water and air pollution programs, but the possibilities of general support are probably "slim for a subtle policy specifying so much reduction of pollution here, a little less there and none someplace else." A difficult choice may have to be made between too little effort to reduce pollution and too much effort in relation to competing national goals.

Wildavsky's conclusion is that we should stick with the "old economics," working to increase its capability and to expand its scope. The critical need is for a greatly expanded information base to help improve the objectivity of political decisions that must be made with or without adequate information.

STRATEGIES FOR REDEPLOYMENT OF ANALYTICAL CAPABILITY

The foregoing discussion has briefly sketched the economic rationale for government intervention, highlighted some of the problems in current benefit-cost procedures, emphasized the multiple objectives and fragmented decision powers in the political environment of resources programs, and reviewed briefly some proposed reforms in current evaluation practice. Where do we go from here? The institutional setting of Federal evaluation practices plus the inherent uncertainty of radically different approaches means that we must start from where we are to reform the present practices incrementally and sequentially.

Guidelines Provided by the Congress

The Flood Control Act of 1936 specified that flood control projects could be assisted "if the benefits to whomsoever they may accrue are in excess of the costs, and if the lives and social security of the people are otherwise adversely affected." [11] The types of benefits and costs were not specified. The subsequent "Green Books" specified limitation of analysis to national income gains primarily, but they had no official congressional sanction nor uniform agency concurrence. [12]

[11] Flood Control Act of 1936 (49 Stat. 1570).

[12] Subcommittee on Benefits and Costs, Proposed Practices for Economic Analysis of River Basin Projects, U.S. Fed. Inter-Agency River Basin Comm., May 1950, rev. May 1958.

Senate Document 97 was prepared at the request of the President, approved by the Secretaries of Agriculture; the Army; Health, Education, and Welfare; and the Interior, and printed as directed by a Senate resolution in 1962.[13] The potentials this document provided for effective evaluation to support informed political decision-making have not been realized. The planning objectives set forth are multiple and the instruction to consider national, regional, State, and local viewpoints recognizes the fragmented structure of control that exists.

The basic objective expressed in SD 97 is to provide for "all foreseeable short and long term needs." The objectives section goes on to state that "national economic development," "development of each region," "maintenance of national strength," "satisfactory levels of living," "preservation for best use when needed," "recreation," "inspiration, enjoyment and education of the people," and "hardship and basic needs of particular groups shall be of concern," and "care shall be taken to avoid resource use and development for the benefit of a few or the disadvantage of many."[14]

These are not all operational economic terms. However, they do represent social goals and values now recognized in the political environment. The challenge is to include additional analytical information on these values in project plans now and to progressively modify our analytical procedures to incorporate them as central objectives in our analyses. Modifications can be tried on an experimental basis until acceptance is gained.

Many project plans, for example, now lack the most elementary information on the economic and employment conditions of the people living in the immediate impact area of the project. This information could be assembled from Federal and State sources. Also, there is often little or no attempt to specify the economic and social characteristics of the individuals and groups who stand to gain, or lose, from project installation. Reliable estimates of the characteristics of gainers and losers could be rather easily developed. Fortunately, research is currently aimed at developing sophisticated approaches for analyzing these project effects.[15]

Strategic Studies of Resource Development

In planning for the development and preservation of natural resources there is a fundamental need for information that provides a continuing overview of our natural resources and trends in their relative values and uses. This overview is essential for assessing the combined effect of the various resource programs.

Scattered studies have provided this kind of perspective. For example, Schultz has indicated the declining relative importance of natural resources in our productive activities.[16] Krutilla has emphasized the shifting trade-offs between productive and aesthetic uses of our resources resulting from technological improvements.[17] Such major trends in resource values are not revealed by the continuing series of project studies.

Krutilla also warns us of the "tyranny of small decisions" in resource development. Sequential and unrelated project-type decisions can lead to a composite pattern that ignores minority but significant values—for example, concern for wildlife—or results in patterns of use inflexible in their capacity to adjust to emerging problems and changing social values—for example, agricultural versus municipal water use or residential development versus parks.

A number of strategic studies of resources have been undertaken. These include the Timber Resource Reviews, the Conservation Needs Inventory, the

[13] Policies, Standards, and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources, S. Doc. No. 97, 87th Cong., 2nd Sess., May 1962.

[14] Ibid., pp. 1 and 2.

[15] In addition to other papers prepared for this symposium, see Robert Haveman and John Krutilla, "Unemployment, Excess Capacity and Benefit-Cost Investment Criteria," The Review of Economics and Statistics, Aug. and Nov. 1967, also available as Reprint No. 70 from Resources for the Future, Inc., Wash., D.C. See also "Income Redistribution Effects and Benefit-Cost Analysis," by Burton A., Weisbrod; "The Use of Shadow Prices," by Roland N. McKean; and accompaning discussions in Problems in Public Expenditure Analysis, Samuel B. Chase Jr., ed., The Brookings Institution, Wash., D.C., 1968.

[16] Schultz, T. W., "Connections Between Natural Resources and Economic Growth," Natural Resources and Economic Growth, Resources for the Future, Wash., D.C., 1961.

[17] Krutilla, John V., "Conservation Reconsidered," American Economic Review, Vol. LVII, No. 4, Sept. 1967, pp. 777-786.

National Assessment of Water Resources, the Outdoor Recreation Resources Review Commission's recreation studies, the National Wild Rivers Study, the National Interagency Regional Analyses and Projections studies of the Economic Research Service, and others. More of these studies are required, and the capability for continual updating of this information needs to be improved. There is also a need for developing a simulation capability that will permit testing of program impacts on the indicated trends in resource uses. Finally, there is a need to relate this overview information to operating programs and to modify project purposes and locations based on the results obtained.

The present practice is to plan a project and move on to plan another project, never looking back to see if previous anticipations were borne out. It has become almost routine, in gatherings such as this, to call for ex post studies of installed projects. However, little has been done in this area and the need is still with us. There is a reluctance among planners, and probably in the Congress as well, to expend effort to uncover old mistakes, but the unrealized expected benefits might be balanced in large degree by finding unexpected benefits, particularly in the areas of associated economic effects, recreational use, and water quality improvements. There is a definite need to learn from our experience. This we are now choosing not to do.

It is commonly believed that the inclusion of "secondary" objectives will result in significant losses of potential national income benefits. Where is the proof? There is little empirical information indicating the degree to which the various objectives of public policy are in fact inconsistent.[18] Uniformed dialogue on these issues may establish a polarity that is more apparent than real. The question is still open. Some research is needed to resolve it.

CONCLUSIONS

Federal natural resources programs and projects are not economically justified, they are politically justified. Economic considerations are important but our elected representatives make the decisions. Major classes of social goals may be classified as economic development, equity, social welfare, and national security. The influence of these considerations shifts with changes in the political power structure, with historical events in the short run, and with changes in social values and historic trends over time.

The governmental structure in the United States, because of interaction between units and with groups in the society, results in fragmented decision-making. No one agent or group is permitted to act without actual or potential consultation or cooperation with or review by others. The "separation (fragmentation) of powers" is a principle of our institutions antecedent to and expressed in the Constitution.

The central thesis of this paper is that economic planning, focusing solely on one of several social and political objectives, is not adequate for providing a factual basis on which efficient political decisions can be made. It is recommended that the focus of analysis be broadened to include the relevant social and political objectives. Information on the socioeconomic characteristics of benefited groups, for example, is now available and can serve to make current analyses and plans more useful. Additional information sources must be developed. Progressive modifications in the current analytical procedures will be needed to incorporate and assess information relevant for political decisions.

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[18] See discussions in Maass, op. cit., and Stephen A. Marglin, Public Investment Criteria, The M. I. T. Press, Cambridge, 1967, p. 39.

II. THEORETICAL CONSIDERATIONS

CONCEPTS AND THEORETICAL BASIS FOR EVALUATION OF SECONDARY IMPACTS

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In 1950 the question of secondary benefits or pecuniary economies was regarded as the least well developed question in benefit-cost analysis. It remains so today. The American mind is an engineering mind and easily grasps the reality of technological spillovers like air and water pollution. It requires some conceptualization to see the reality of pecuniary spillovers, and to the concrete mind what is merely abstract is only imaginary. Mason Gaffney, 1966.

All I have to say "stems from" or is "induced by" our failure to satisfactorily come to grips with the concept of secondary benefits, either theoretically or empirically. The major thesis of this paper is that to improve our project evaluation procedures, we must go beyond an economic efficiency concept which still pervades much of the project evaluation literature.

Some theorems of conventional welfare economics that underlie the concepts of secondary benefits as expressed in the Green Book and other Federal policy guides will be briefly noted.[1] It will be shown that the concepts of secondary benefits found in the Green Book have their origin in the theoretical underpinnings and assumptions of microstatic economics (24). Some fundamental weaknesses and inadequacies of conventional concepts will be examined and some tentative suggestions for the redirection of theory offered.

A major purpose of this paper is to assess the relevance of conventional economic theory for evaluating project impacts. It is generally maintained that equilibrium theory which leads to the evaluation of impacts on a criterion of net national income gains is too restrictive to adequately assess the full impact of resource development projects. Some reasons for this contention and for the need for a theoretical framework oriented toward dynamics and economic growth will be discussed. An essential aspect of a more appropriate framework is that it will have to come to grips with an evaluation of the role of natural resource development in economic growth. Such a framework remains largely a research frontier, which precludes the development of a theoretical framework comparable in elegance to the static equilibrium theory of conventional benefit-cost analysis. However, we might be consoled by remembering that it is . ."better to obtain an approximate answer to some of the relevant questions than a precise formulation of the irrelevant" (11).

THE RATIONALE FOR SECONDARY BENEFITS

To understand the conventional views of secondary effects, it is necessary to understand something of the underlying theory on which the concepts are based. The concepts expressed in the Green Book are not arbitrary but follow somewhat logically and directly from acceptance of the assumptions and postulates of microstatic economic theory. Thus, if we wish to look for the rationale of these expressed concepts, we must go back to the theory from which they derive.

Concepts and Definitions

The most commonly used concept of benefit stems basically from the classical theory of consumption. The benefit of a project to an individual is taken to be that amount of money which he would be willing to pay for its services (3). This concept is in keeping with competitive consumer demand theory, which holds that the amount an individual is willing to

[1] For a more complete discussion of the theoretical foundations of benefit-cost analysis, see (4) (15) (16). These and other numbers in parentheses refer to Literature Cited, as listed at the end of this paper.

pay for a product or a service is a valid measure of its value. Primary (direct) benefit is defined as the value of the immediate products or services resulting from project investment. Indirect (secondary) benefits are defined as "the values added by incurring secondary costs in activities stemming from or induced by the project" (24).

"Stemming-from" benefits are those that accrue from increased processing of goods produced by (or on) the project. "Induced-by" benefits are those resulting from added purchases by producers. These added purchases increase local business profits, which in turn are translated into increased demand for goods in the general local economy. I shall argue that these are usually real and significant changes in net income in the local area only and that the Green Book is usually correct as long as the criterion is net national income gains. There is a real danger of overcounting by simply summing these two types of benefits. Kelso has argued that, in practice, secondary benefits stemming from and induced by a project are actually cases of increased supply and demand, respectively, which have been incorrectly summed in some project evaluations (9).

Conceptually, there is no useful purpose to be served by a separation of changes in income to local residents, other than the direct beneficiaries, into induced-by and stemming-from benefits. The kind of local secondary effect does not matter. What matters is who benefits, and by how much, and who pays the cost.

Project Feasibility

The emphasis on the necessity for economic quantification of costs and benefits of projects can be traced back to the Flood Control Act of 1936. Among other things, this act laid the foundation for the favorable B/C ratio, specifying that benefits must exceed costs. . ."to whomsoever they may accrue" to qualify for congressional authorization. Such a criterion requires no consideration of the distribution of benefits, the implicit assumption being that the aggregate benefits will have the same value regardless of the manner in which they are distributed. This idea is closely akin to the idea of constant marginal utility of income.

A favorable B/C ratio has been an operational necessity for determining feasibility and justification of projects, even if it has never been a legislative requirement. The fact that a favorable B/C ratio is taken to indicate a project's desirability can be inferred from such statements as: "A ratio of benefits to costs of greater than one is usually regarded as an indication that the proposed work should be undertaken" (22). Thus, if the B/C ratio is an indication of project desirability, obviously any agency would like the ratio to be as high as possible.

National Secondary Benefits

The Green Book considered two conditions under which national secondary benefits could arise. The first was that the market value of project surplus would be greater than the cost of producing an equivalent surplus in the project's absence. The other condition was based on underutilization of resources. The Department of the Interior established a panel of consultants to supplement the authoring subcommittee's work. Two years later, a revised statement on secondary benefits was issued to clarify and supplement the earlier report. It concluded that a favorable B/C ratio was a necessary condition for the existence of secondary benefits, unless underemployed resources were used in project construction (23). By and large, the panel agreed with the subcommittee but concluded that the resources used in the project had alternative uses and that the value of these alternative uses must be considered in project evaluation (23). In the revised Green Book published in 1958, most of the basic principles of the original were retained and a distinction was made between national and regional or local secondary benefits. For economic justification of projects, net national secondary benefits were the sum of gross secondary benefits minus the direct cost of these secondary activities and minus the secondary benefits that would have occurred from other uses of the resources required in the projects. Concerning local secondary benefits, the report held that only the cost incurred in secondary activities should be subtracted from gross secondary effects to obtain net secondary benefits and inferred that the local secondary effects might be appropriate for cost-sharing determinations. The Green Book concluded that:

> Although secondary benefits may be significant in the economic justification of projects from a local or regional point of view or in reimbursement and assessment considerations, . . .from a national public point of view such benefits usually have little significance in project formulation, economic justification, and array.

This conclusion follows logically and directly from the normal assumptions of microstatic economics where the "public point of view" is equated with the maximization of net national income. Thus, the conclusions are perhaps sound if the theoretical assumptions and criteria on which they are based are

deemed to be a proper framework for evaluation. Senate Document 97 contains some refinements but retains the basic concepts of secondary benefits, defining them as any "increase in the value of goods and services which indirectly result from the project as compared to those without the project" (14). Thus, the conceptual framework has remained relatively intact. SD 97 does, however, specify that all viewpoints—local, regional, and national—are to be considered. On many points, SD 97 remains silent on the details.

Other Categories of Secondary Benefits

Kneese enumerates three types of secondary benefits: (1) Those due to external economies, (2) dynamic secondary effects, and (3) the "customary" variety associated with those effects stemming from and induced by the project (10).

The first two types would appear to be conceptually closely related. In fact, it could be argued that the above paragraph only specifies the necessary conditions for secondary benefits; that is, all secondary benefits are "dynamic" and "external" in some sense and either stem from or are induced by some stimulus. Although the above categories may be useful, I find it difficult to consider the classifications as mutually exclusive. The first category is associated with the most conventional form of external effects; that is, those based on the technical interrelationships among separate units in an economy. The second category is based on the assumption that the project will stimulate economic efficiency by introducing more advanced techniques and by generating employment of more skilled labor. Another concept is that a project in sparsely populated regions will result in more efficient use of existing social overhead capital (12). Conceptually, I find this second category to be little, if at all, different from that often found in economic development literature and usually referred to as "development externalities" (1) (2) (19).

Regional-National Relationships

Much of the debate concerning secondary benefits centers around the issue of national-regional competitiveness. If the assumptions of a neoclassical competitive economy are met, there is little basis for expecting secondary benefits to contribute to net national income, since any gains in the region will be fully offset by losses somewhere else. [2] Using the criterion of net national income gains, national secondary benefits must be limited to those resulting from the conditions classified by Kelso in 1952. These conditions are: (1) Employed resources are shifted to more productive use, (2) employed resources are employed closer to optimum capacity, and (3) unemployed resources are employed as a result of the project (9). It should be noted that the existence of one or more of these conditions is not sufficient for the accrual of positive national secondary benefits given the objective functions. Such gains are, of course, regional gains as well as national gains. However—unless the secondary benefits arise in this way—that is, unless they are not the result of transfers from other localities—the income gain is local but not national.

The problem of determining regional and interregional transfers and competitiveness is far from being satisfactorily resolved. As long as the criterion of net national income gains is adhered to, the problem of netting out regional and national benefits will remain. It is obvious that we do not know enough about the complementary and competitive relationships within and between regions to feel much confidence in generalizations.

In order to legitimately count secondary effects as contributions to net national income, it is essential to count as part of the alternative cost all the secondary benefits that would have arisen had alternative investments been made. Thus, the measure of net national secondary benefits is the net difference in secondary benefits arising from project investment compared with net benefits arising from an alternative investment anywhere in the economy. There may be instances in which this difference is positive and significant, but it is difficult to conclude this from a priori knowledge.

An Example of National Secondary Effects

If a potential project area has widespread unemployment, a project may serve as an employment generator. In such cases, there may be national as well as local secondary benefits accruing to a project. It has also been argued that such projects serve to develop the skills of the local labor force. However, it seems more appropriate to recognize that at least part of this effect, if it does occur, results from the reduction in costs rather than increased benefits. Nevertheless, this effect may in fact be significant, as has been recently demonstrated.

The rationale for using market prices of factors in computing construction costs is that, given full

[2] Major assumptions are: (1) Full employment; (2) perfect factor mobility; (3) perfect knowledge; and (4) no external economies or diseconomies.

employment and efficiently functioning factor markets, market prices reflect real cost. Although this framework is usually adopted, most analysts have recognized the desirability of adjusting factor costs in periods of substantial unemployment. In a recent study, Haveman and Krutilla have attempted to empirically estimate the true opportunity cost of labor used in project construction by relating the major occupational categories used to the unemployment rates in these particular categories (5). Using a model designed to estimate the primary resource requirements of any final expenditure, they were able to relate the occupational and industrial demands on the economy by several types of water resource investment.

Based on 1960 conditions, they conclude that the opportunity cost of project construction from 1957 to 1965 was between 65 and 85 percent of nominal money cost, depending on which is the most accurate response curve relating probability of drawing from idle labor pool to unemployment rate. As might be expected, dredging, local flood protection, and construction of small earth fill dams had a lower opportunity cost than construction of powerhouses, large dams, and locks. We might expect this since more unskilled laborers (the group with highest unemployment rates) would be demanded in the former types.

Without putting an unwarranted amount of faith into the empirical results, I think it is important to see the possibility of making some estimates of the real opportunity costs in project areas where unemployment rates are above minimum levels. This may indeed be a significant secondary effect of project construction. Perhaps this type of opportunity cost analysis applied to various types of public investments might shed light on the differential impacts of different investments. This type of research might provide some clues as to what mix of investments could be made to meet multiple policy objectives, and is, therefore, badly needed.[3]

Local Secondary Effects in a National Perspective

In considering secondary benefits from a local point of view, the theoretical base is more solid, even when based on conventional theory. It is generally true that secondary benefits tend to be local in nature, while secondary costs tend to be national. An increase in economic activity in the project area almost always benefits the local area and improves its comparative advantage relative to nonproject areas. However, the benefits going to the local area may be partially or fully offset by corresponding losses to competing areas. If we are interested in local development only, we have no problem. However, if we wish only to improve national economic efficiency, we may find it difficult to justify counting local secondary benefits as a contribution to this objective. It seems clear that some of our objectives are local in nature, and properly so, and that it might be time to explicitly recognize other objectives and criteria in addition to national efficiency.

Several empirical studies to measure local secondary benefits have been undertaken in recent years, (6) (7) (8) (13). A number of these have emphasized the secondary impacts of irrigation, recreation, and flood control. Techniques such as Leontief interindustry models as discussed in other papers of this symposium have proved to be quite useful for estimating the magnitude and distribution of local secondary benefits. Our measurement techniques are much better suited to local secondary effects than to national ones. Many of the policy decisions affecting growth and development are made at a local level, and it is extremely important to be able to quantify the magnitude and distribution of such effects.

Public Goods

Resource development projects often create effects that lie outside market transactions. In fact, they may be undertaken for just this reason. While these effects may be tangible or intangible, it seems clear that some goods and services are created by resource development investments that cannot be evaluated in the conventional market demand analysis. Such effects are usually called "public goods."[4]

A public good is defined as one whose consumption by one individual does not detract from its use by another individual, whereas a private good is one whose use by one individual reduces the utility others may derive from that good (17). One of the major implications of this distinction involves the construction of market demand curves. The market demand curve for a private consumption good is simply the horizontal

[3] A somewhat related idea is contained in a recent article that argues for a strategy of cross-commitement with respect to poverty and water pollution control. See (21).

[4] This concept is explored more fully in the preceding paper by Gary Taylor. It should be noted that the distinction between "public goods" and "private goods" is not the same as the distinction between "primary goods" and "secondary goods." Public goods may be either primary or secondary.

summation of individual demand curves However, the construction of a market demand curve for a public good requires a vertical summation of individual demand curves. By its nature, if a public good is provided for individual A, it is automatically available for others. Thus, it is always in the best interest of an individual acting rationally to understate his demand for a public good. This raises important policy questions concerning the difficulty in measuring benefits of such goods through market demand information and in determining the distribution of the burden of the cost of a public good. Because such a commodity must serve everyone regardless of his contribution to its provision, there are no clear-cut guides to allocating cost. Public goods are an example of an externality that may confer beneficial effects on other parties without any compensation.

Self-interest leads each person to desire to depend on other consumers for the provision of public goods. The rationale for provision of these goods by government is "precisely because each individual in uncoordinated pursuit of his self-interest must act in a manner designed to frustrate the provision of these items" (18). In other words, the conventional market mechanism may provide less than socially optimum investment in public goods.

Scenic values, pollution control, flood protection, recreation, and several other water "products" contain characteristics of public goods. The point to be emphasized is that the benefits of investments in the provision of public goods are likely to be undervalued when one uses conventional market demand information. The market may not provide the proper price signals to decision-makers. Obviously, this does not suggest that all resource development investments are justified because they create potential public goods.

TOWARD A NEW THEORETICAL BASIS

I have emphasized that project evaluation has been based on general or partial static equilibrium analysis. An implicit assumption is that any direct interdependence is expressed through market prices. Uncompensated externalities are the bug-a-boo of general equilibrium theory.

Pecuniary (market) externalities are all-pervasive since market interdependence exists throughout the market. They are in contrast to technological externalities, which fall outside the market mechanism. In equilibrium analysis, pecuniary externalities are considered irrelevant since, given the assumptions of equilibrium theory, they involve purely intramarket transfers. While developmental pecuniary externalities have no place in static equilibrium, they can be a most important element in the evaluation of the total impact of investment in resource development.

It seems reasonable to evaluate any program on the basis of its contribution to explicit objectives. Certain serendipitous effects are always welcome, but there is nothing noble about doing the right things for the wrong reasons. Likewise, it is not very satisfying to an economic analyst to have to disguise the kinds of effects desired under an objective function which makes such effects slightly illegitimate.

Most resource development projects are often expected to favorably alter the process of economic growth. Since growth is a dynamic process, it is difficult to see how the contributions of a project to a dynamic objective can be properly evaluated in a static, microeconomic, general equilibrium framework. Natural resource development programs often create primary and secondary effects that contribute to certain goals such as economic growth and development, income redistribution, reduction of unemployment and improvement of labor skills, balanced growth, social well-being, amenities, and intangibles. Some, but not all, of these effects can be picked up in the framework being used.

What seems to be called for is a general economic growth and development framework within which the contributions to objectives of particular investments can be evaluated. Basic to our concern with evaluating the impacts of natural resources development projects is the question of the role of natural resources in economic development. Another fundamental issue is that to be able to evaluate the contributions of projects to overall goals and objectives, one must know what those goals and objectives are. Once the goals have been specified, the economist is in a better position to structure his analysis to provide relevant information.

I would like to suggest some steps toward a reorientation of project evaluation, some steps which on the surface may not look very different from conventional methods, but which I maintain are crucial to a new theory of resource economics.

1. Specify (explicitly), before analysis begins, the policy objectives toward which the project is to contribute. The project should be evaluated on the basis

of its effectiveness in contributing to the goals and objectives for which it is undertaken.[5]

2. Consider alternative means of meeting the objectives, including alternative mix of project purposes and/or alternative projects which would be most efficacious in achieving objectives. Although the economist possesses no skills that uniquely qualify him to determine policy goals and objectives, he may at times be in a better position to consider alternative objectives suggested by insight gained through analysis of alternative means. After all, the essence of economics is consideration of alternative choices, and the separation of ends and means are not as clearly independent as is often believed.

3. Specify the contribution the project will make (or has made) toward the objectives. No claim is made that all such effects can be economically quantified. Certainly it is not likely that all the effects of the project can be fitted into the B/C ratio. However, quantification can take us a long way, and the methods of quantification must be suited to measuring the effects the project is designed to bring about.

4. Identify competitive and complementary effects among multiple objectives of the project and among project purposes. Little is known about the relationships among different effects and objectives. Knowledge of such relationships could aid in the formulation of programs and projects to achieve multiple policy objectives.

Resource development projects are obviously expected to contribute to multiple objectives, not the least of which is economic growth. We need to know much more about the effectiveness of resource development investments in contributing to this and other goals. Perhaps the need is for some ex post research oriented toward determining the role of such investments in creating potential and actual growth, the forward and backward economic linkages, and the developmental externalities created. Such information would be helpful in designing programs to take advantage of complementary and competitive relationsips in the economy. We need more knowledge concerning the mix of projects and project purposes that are likely to be more efficacious in achieving desired objectives.

Heavy reliance on microstatic theory has led to too much emphasis on project justification and not enough on project effectiveness. But as Weinberger reminds us, "Evaluation of secondary benefits has little practical value in the formulation of public investment plans unless, included among the purposes of investment are increased employment, economic development, or some degree and kind of income redistribution" (25). I see little merit in trying to rationalize secondary benefits in an analytical framework that is incapable of considering such objectives. The real need is for a framework that can permit the inclusion of such purposes and effects without apology.

[5] Effectiveness need not mean efficiency in the usual sense, and evaluation is not the same thing as justification.

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SECONDARY EFFECTS OF LAND AND WATER DEPLETION

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The term "depletion" is used in this paper in an unusually broad sense. It connotes loss of soil by wind, sheet, gully, or streambank erosion; loss of agricultural land through inundation with water as a result of the building of dams; and loss of ground water supplies through rate of utilization exceeding rate of recharge. The discussion in this paper starts with the assumption that land depletion and water depletion have similar economic and social effects.

The main intent is to review the applicability of existing concepts for evaluating so-called secondary effects that may be associated with depletion. Because some secondary depletion effects may be remote and obscure, the analysis has a two-pronged purpose: To ensure that every effect attributable to depletion, or its control, is considered explicitly and counted if possible; and to ensure that each effect is counted only once in evaluation procedures. The analysis is therefore mainly related to theoretical problems of identifying and tracing secondary effects.

The ensuing review begins with a brief statement on general theoretical orientation. Next, the concept of primary depletion effect is introduced. Following this is an elaboration on various types of secondary effects. Finally, attention is directed to the case of ground water depletion in the High Plains of Texas as a specific problem.

"WITH AND WITHOUT" FRAMEWORK OF ANALYSIS

The "with and without" approach is adopted as a general framework of analysis. Although this approach has the advantage of providing symmetry in the procedure for evaluating depletion effects, it may appear to be awkward or negative. The positive approach would be to assume that investments are to be made for control of depletion and then proceed to evaluate the effectiveness or consequences "with" and "without" the investments involved. While this procedure would be quite plausible for land erosion or ground water depletion, it would not be so for inundation of land by a reservoir, because no investments are ordinarily made for the latter. Erosion of land or depletion of ground water supplies are processes whose damages can be reduced by investments, while inundation is an occurrence whose damages are incident to investments incurred for other purposes.

Inherent in this approach, however, are potential dangers that should be noted. The term "depletion" implies that the effects will be generally detrimental or negative, and comparisons of the situations with and without depletion should give some indication of the effects in terms of costs, or benefits foregone. However, these costs, or benefits foregone, would be more accurately evaluated if assumptions are made as to the optimal level of investments for development and growth, and the differences between this situation and the situation with no investments are compared.

The main point is that the without-depletion situation should imply an optimal state; otherwise, the effects of depletion will be understated. This proposition is based on the premise that some of the secondary effects are functionally related to the gross primary effects of depletion rather than to the net primary effects of depletion. The gross primary effects depend upon the level of investments or development for sustaining or increasing production. It is generally accepted, for example, that investments for erosion control maintain as well as enhance production, even though this need not always be true. If the enhancement foregone is ignored in evaluating the depletion effects, some of the secondary effects might be omitted. Thus,

projections of consequences without depletion should include allowances for any effect of investments to increase production.

Under these assumptions, results of analyses from either the positive or negative points of view should lead to essentially the same conclusions. However, the interpretation of results will differ. From the negative viewpoint, the expected net effects would be in terms of depletion costs or net gains foregone. From the positive viewpoint, the expected net effects would be in terms of net gains.

The analytical framework should also be modified to account for differences in the functioning of resource markets within an expanding or a declining local economy. For instance, in a declining local economy, sunk investments must be considered. This problem will receive special consideration in the discussion of ground water depletion in the High Plains of Texas.

PRIMARY EFFECTS OF DEPLETION

The concept of primary depletion effects needs to be clarified before we discuss the secondary depletion effects with which we are mainly concerned. The primary-secondary classification is equivalent to a dichotomy in which the secondary effects are invariably treated as the residuals after primary effects have been isolated. Secondary effects therefore depend upon definitions of primary effects and, in practice, include tertiary or more extended and roundabout effects.

The net primary effects of land or water depletion are equivalent to the reduction or loss in economic rent (returns to land, water, or both considered compositely as a resource). Depending on the viewpoint of accounting, this rent would be, or would have been, the contribution of land and related water resources to production or to the income of landowners, regions, or the Nation. The loss in economic rent through either erosion, inundation, or ground water depletion would constitute a prime cost.[1/] The gross primary effect would be, of course, the gross production lost.

[1/] In the watershed protection program, the returns to land are considered only as a part of the primary effect, presumably because joint investments are made for both erosion and sedimentation control, and the "primary" concern is broader in scope than soil depletion. Cf. Soil Conservation Service, Economics Guide for Watershed Protection and Flood Prevention, U.S. Dept. Agr., Mar. 1964, chs. 5 and 11.

The preceding definition of net primary effects rests on the assumption that the resources which otherwise would have been used in combination with land for agricultural production would not be idled by the depletion. Instead, they would earn at least an equal reward elsewhere in the economy. The conclusions would be modified should the assumption be changed or should such investments cause capital losses upon a decline in economic activity.

SECONDARY EFFECTS OF DEPLETION

According to the prevailing dichotomy of overall effects, secondary effects are defined naively as the nonprimary or indirect effects. Some of these effects are, however, functionally related to the primary effects, while others are not. Most of these functionally related secondary effects can be put into the conventional categories of "stemming-from" and "induced-by." Other secondary effects that can be derived may be classed as either "side" or "correlative." The following discussion is directed to the theoretical basis for claiming these various categories of secondary depletion effects.

"Stemming-From" and "Induced-By" Effects

Most of the literature on secondary effects has been concerned with those that may be classed as "stemming-from" and "induced-by." In agriculture, stemming-from effects are conceived as those related to the activities in economic sectors handling, processing, or distributing agricultural production for consumption. Induced-by effects would be those related to input-provision activities of the sectors that supply resources for the agricultural production processess.[2/] Generally, the concepts appear to be more useful for the case of soil or water depletion than for land inundation, because after the land is covered with water the activities that would have been generated by the use of the land for agriculture are no longer alternative possibilities. The

[2/] Cf. Soil Conservation Service, ibid., ch. 11.

It may be noted that the stemming-from and induced-by effects are analogous to Hirschman's "forward-linkage" and "backward-linkage" effects, respectively. Hirschman's concepts would probably be more meaningful if the analysis were cast in the context of economic development and growth. One might raise the question, however, whether there are any important "lateral-linkage" effects regionally for agriculture in addition to the "forward" and "backward" linkages. Albert O. Hirschman, The Strategy of Economic Development, Yale University Press, 1958, ch. 6

concepts may be useful for the inundation case, however, in recognizing the possible foregone effects.

The interrelationships among depletion and stemming-from and induced-by effects are theoretically close and are a result of agricultural producton functions. For stemming-from activitities, these production functions underlie the supply functions of the raw material needed for processing and distribution. For induced-by input-provision activities, they underlie demand functions for inputs in agriculture. Thus, because depletion causes downward shifts of production functions, levels of both stemming-from and induced-by activities are jointly affected.

Distinction must be made among soil erosion, ground water depletion, and inundation effects in specific instances. For example, in the general case of erosion, production functions may only drop gradually to lower levels; in case of ground water depletion, production functions may drop rapidly, and, in the inundation case, they always instantaneously become nonexistent. In any case, however, both the supply and demand functions are affected.

The connection between stemming-from and induced-by effects long has been recognized. This has led to the suggestion that only one or the other of these types of effects should be counted to avoid duplication. But these two categories of effects should not be regarded as substitutes. [3] Separate estimates of net stemming-from and net induced-by effects are needed. The magnitude of these two categories of effects depends upon different variables, even though they are both connected by the agricultural production functions. The respective firms or industries in which the stemming-from and induced-by effects are felt should be expected to have their own sets of cost functions. These may differ and therefore will influence the relative net gains or losses in each affected secondary firm or industry. [4]

Response in secondary production to changes in primary production also will depend on the current or previous state of development, the scale of activities, and the proportions of costs that are fixed. When economies due to larger scale (decreasing costs) are present, the net secondary effects can be expected to be larger than in other instances. This would also be true when the fixed resources have no alternative sources of employment; that is, the associated fixed costs would be proportionately high.

Economic activities affected locally or regionally by depletion will, in turn, affect regional income and employment. These effects would be particularly significant in times of underemployment. On the other hand, the economy of the region may be stabilized or stimulated if depletion is minimized. If depletion is permitted, the interaction effects could probably be expressed as a kind of negative-multiplier effect due to loss in production, income, and employment that would otherwise have been generated or sustained had efforts been made to keep agriculture viable. It is possible that these negative effects, in the long run, could result in abandonment of agricultural land, decay of communities, or depopulation.

The possible stemming-from and induced-by effects are hard to visualize from a national or interregional point of view. Nationally, the effects would depend upon the scarcity of the particular grade of resources affected, the relative volume of primary production lost, the availability of substitute products, and the role of technology.

Changes in primary production or income caused by depletion in relatively small pockets may be marginal and insignificant in a national context. The associated secondary economic effects would be negligible. With resource mobility and competitive markets, interregional adjustments in land use and production should be compensating. The situation would be different,

[3] The SCS evaluation manual uses "change in profits" as a proxy for the gains (benefits) from erosion control. These gains would accrue to local wholesalers and retailers, transportation, marketing, processing, and farm supply businesses. The secondary effects on the cost side are not given equal clarity, however, In practice, estimates of "stemming-from" benefits would be included in a capitalized value of the production saved. In contrast, the "induced-by" effects would be estimated as 10 percent of the difference in the cost of the primary producers. (Cf. Soil Conservation Service, ibid., ch. 11 pp. 3-4.)

[4] In trying to trace the incidence of these stemming-from and induced-by effects, it may be helpful to think of them as externalities from the viewpoint of agriculture. These effects are felt in the nonagricultural industries or sectors, and are probably more pronounced in the industries linked immediately with the agricultural production, but certainly do not necessarily stop abruptly with those industries.

however, for sensitive crops which cannot be grown successfully under a wide range of physical conditions, or for large areas of resource depletion such as the High Plains of Texas. In addition, even though the marginal contribution to total national income of land and related water in any given location may be negligible, depletion may be of national significance should there be a public desire for interregional balance in production, income, and growth.

"Side" and "Correlative" Effects

Although attention has been given almost exclusively to stemming-from and induced-by effects in resource development analysis, other secondary effects also may be significant. Some of these effects are likely to be overlooked or ignored because they are not as tangible or visible as the production, income, or profits related to stemming-from or induced-by activities. Nevertheless, they may be important from other viewpoints, such as income distribution, social costs, or local governments.

Among other secondary effects are those that may be classed as "side" effects and "correlative" effects. These distinctions are arbitrary. Generally, however, side effects are those caused by the institutional environment, while correlative effects are those caused essentially by the physical environment. The side effects could also be referred to quite descriptively as "spillover" effects and the correlative effects as "off-site" effects which implicitly depend on the physical boundaries of the analysis.

Side effects of depletion may be denoted by disproportionate changes in land values in the zone of influence of the affected areas, with consequent gains to some and difficulty in property acquisition for others. These effects might also include reduction of the property tax base; increased cost of acquiring comparable land; severance damages; and loss of asset values, income, and employment in making readjustments. These types of effects, although local or personal as to their incidence, nevertheless may be significant, depending upon public objectives, because they carry such implications as income and wealth distribution.

Many other possible side or spillover effects could be listed, of course. But these need not be a result of resource depletion per se. These might include disruption and cost increases in community services, costs of displacement and relocation of people, losses on forced sales of personal property, business interruption and loss of good will and patronage of a going concern, and other effects that are not easily quantified.[5]

As defined here, correlative effects are functionally related to the soil movement that results in depletion. The effects are therefore relevant for erosion only. They might include sedimentation damages to transportation systems, businesses, or residences; to water supply or drainage systems; or to reservoirs. Some of these damages may still have further or extended effects if they cause serious inconveniences or interruption of services. Also among the correlative effects, one might include air pollution by dusts, as well as siltation of streams or rivers affecting wildlife or recreational use of the water. Some of these effects, such as sedimentation damages, would be regarded as primary effects under the Federal watershed protection program.[6] This classification is reasonable because of the jointness of control measures and the related investments for both erosion and sedimentation. It also serves to illustrate the point that nothing is sacred about any primary-secondary classification of effects. The classifications are flexible; and the usefulness of the dichotomy depends upon the purposes of evaluation.

The incidence of these side or correlative effects may be expected to vary. This suggests that it will be necessary to examine all conceivable facets or segments of the economy in identifying or in attempting to trace them. Some of the side effects may be felt by farmers through severance damages resulting in losses in efficiency. Others may be felt by landowners or renters through changes in land values or rental, by local governments through reduction or shifts in the sources of revenue, or by local taxpayers through distribution of the tax burden.

From a local or regional point of view, changes in land values create an environment for interpersonal redistribution of wealth. Current property owners, in the areas where depletion takes place, would be the potential losers. The secondary effect on the region depends upon whether the individual gains are exported from, or reinvested within, the region.

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[5] For a listing of the possible effects of inundation of developed areas, consult Committee on Public Works, U.S. Congress, Study of Compensation and Assistance for Persons Affected by Real Property Acquisition in Federal and Federally Assisted Programs, U.S. Government Printing Office, 1965, pp. 105-106.

[6] Soil Conservation Service, op cit., chs. 5 and 11.

While the side effects may be personal or local as to their incidence, the correlative effects may be of interregional or national significance. For example, air pollution by dust caused by wind erosion is not coterminous with any economic region or particular location. Such correlative effects may be widely diffused and, therefore, significant as a national social cost. Siltation of water and sedimentation damages also may be of national importance. Thus, a major distinction in the national significance of erosion and inundation is the difference between these two types of land depletion in their correlative effects.

THE CASE OF WATER DEPLETION IN THE TEXAS HIGH PLAINS

Depletion of ground water threatens many parts of the United States. The Texas High Plains has been singled out for illustrative purposes only. This region is important agriculturally from a national viewpoint because it produces many commodities, including one-sixth of the Nation's cotton and one-third of the grain sorghum.

Of the 8 million acres of cropland in this region, 5 million are irrigated from underground water. This source of water might be depleted if the rate of pumping continues to increase. Continuation of current annual rates of ground water development and use will allow the irrigated acreage to increase further, but this acreage will subsequently decline.

The magnitude of the problem can be illustrated by selected data for 17 contiguous counties in the vicinity of Lubbock. This area encompasses more than half the cropland in the High Plains and about 57 percent of the irrigated acreage. In 1964, this 17-county area produced irrigated cotton worth $195 million and grain sorghum worth $83 million. Together, this production represented 85 percent of the total value of cotton and sorghum produced in the area. If the irrigated acreage currently used for cotton and grain sorghum were shifted to dryland production of these crops, the loss in gross farm income in the 17-county area would be about $174 million. Of this loss, $76 million would be in net farm income and $98 million in gross income to local suppliers of farm inputs. The $76 million represents a reduction of about 30 percent in the net farm income in the area.

If this area is forced to shift entirely to dryland farming in about 15 years, what would be the total cost to the region? Would the magnitude of this total cost differ from that of the total benefits of irrigation development? Research to answer these questions is incomplete, but the expected impacts can be indicated. The 30-percent reduction in net farm income would be in primary farm production. The growing cattle-feeding industry in the region would experience some losses through reduction in the local suppliers of feed grains. Grain elevators and cotton marketing firms would also experience losses. Sectors that produce consumer services would lose from the reduction in household expenditures associated with all local sectors that have significant economic linkage with cotton and grain sorghum production. The tax base supporting local governments would be reduced.

The extent of all these losses to people in the region depends upon the interdependencies of the local economic activities. It depends also upon the degree of fixity of costs of affected firms, the mobility of labor, and the amount and speed of readjustment to the losses involved through new economic activities in the region. These added conditions relate primarily to the functioning of resource markets, or to the rates and costs of adjustment. The sunk (fixed) costs of firms become partial losses in a contracting situation, but they need not be the basis for gains from economies of scale in an expanding situation. In addition, unemployment, or underemployment, of labor is normally more often associated with a declining regional economy than with an expanding one. Productive capacity of firms can be expanded readily at prevailing market prices for resources. But this capacity cannot be contracted by disposal of the capital assets at market prices. Contraction will be associated with loss in the value of capital assets. In addition, with demographic factors being what they are, the population of any growing region normally tends to increase, thus increasing the labor supply. Also, intraregional labor markets ordinarily function more efficiently than do interregional labor markets. Given these conditions, employment rates within regions experiencing economic expansion will be higher than in regions experiencing economic decline and contraction.

The amount of cotton and feed grain production lost in the High Plains of Texas through depletion of the ground water supply could be made up by gains in other regions, but not necessarily at the same unit cost of production. Any loss in efficiency by interregional shifts in production would constitute a social loss. Secondary economic gains in other regions through expanded cotton and feed grain production probably would be less

than the secondary losses in the High Plains. Thus, it appears that on balance the depletion of ground water for irrigation in the High Plains would result in a national economic loss; but the national loss would be smaller than the loss incident to the High Plains as a region.

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REVIEW OF REGIONAL STUDIES OF INCOME DISTRIBUTION

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The purpose of this paper is to reflect on the lessons of the Baton Rouge workshop on income distribution that are pertinent to today's meeting on impacts. Of the many good papers presented in Baton Rouge, some were theoretical, some quite mathematical, and a few very practical. My conclusions today were distilled from participation in the conference and review of the proceedings. Admittedly, these conclusions are tempered by personal views developed over several years of watershed and river basin experience. This eclectic review does not do justice to all the papers presented, but then these papers and their adequate reviews have been published and are available for intensive study.[1/]

My conclusions are that: (1) precise specification of the particular impacts of interest is necessary because of the many different conceptions of impacts; (2) estimation of the distribution of the effects of government programs among people is of greater significance than income expansion effects per se; (3) geographic generality is a more important dimension for impact analysis than comprehensiveness within a specific area; and (4) colloquial or narrow views of impacts should be put into perspective in a more general theory of regional growth. Each of these conclusions is discussed in more detail in this paper.

IMPACT CONCEPTS

Impact concepts can be classified into two major groups. Concepts in the first group are characterized by an overall multiplier or expansion coefficient. A functional relationship between primary and secondary employment effects, for example, is implied. The second classification looks at the distribution of the effects of exogenous influences, such as government programs, on an economy. Impacts in this classification can be further divided into (1) the distribution of effects among sectors or industries in the economy; (2) the distribution among major classes of resources—land, labor, and capital; and (3) the distribution among groups such as urbanites vs. farmers, or rich vs. poor, or upstream vs. downstream landowners.

At the Baton Rouge workshop, most of the papers were addressed to measurement of the distribution of effects among different economic sectors and among major classes of resources. Still, the conceptions of impacts of most importance varied among workshop participants. Indeed, the workshop was criticized by one of the participants because no unifying problem to which the conference participants could address themselves was clearly enunciated. However, one of the unstated purposes of the workshop was to force communication among economists in order to establish common aspects of several regional research projects in initial planning stages. The apparent confusion illustrates the need for a common understanding of the essence of the particular impacts of interests. What economic effects of resource development are of most importance? What is the major role that we can take in analyzing the impacts of resource development programs? If these questions can be answered, and if we agree on the answers, we can proceed immediately to specific methodology; if not, a compromise should be sought.

Several Baton Rouge workshop participants discussed the distinguishing features of some closely related models and concepts. Frank Goode discussed four types of input-output models, while Roger Strohbehn indicated the various types of externalities that we could be referring to when we speak in general of externalities. These kinds of papers are extremely useful if we follow up and develop operational methods of measuring the impacts or externalities of interest. Without this next step the papers become handy references, interesting essays, useful exercises—but not instruments of change.

[1/] Regional Studies of Income Distribution, W.B. Back and John E. Waldrop, Jr., eds., Louisiana State University, Baton Rouge, June 1966.

Sometimes we condemn or promote a general class of models on the basis of a single experience with one type. The real problem in research and planning is to match the specific type of a general class of models to the problem and/or type of answer desired or expected. This cannot be accomplished until we thoroughly understand the conceptual differences among and within the various species of models.

SIGNIFICANCE OF DISTRIBUTION EFFECTS AMONG PEOPLE

Many agency personnel, in their search for benefits, immediately think of secondary benefits when impacts are mentioned. A simple factor that magically expands benefits by 115, 162, or 300 percent is like manna from heaven. Interest-rate increases look much less menancing with these kinds of expansion coefficients.

Promoters of particular programs are most happy to establish the idea that everybody gains from their programs. They fear the disclosure of differential impacts which tend to alienate groups who are adversely affected or who are benefited relatively less. On the other hand, identification and measurement of distributional effects can be carried too far for economists to remain effective in program planning. Evidently, those who planned the Baton Rouge workshop were not concerned about program planning.

The workshop participants virtually ignored these overall expansion coefficients per se. This was deliberate—the intent was to stress income distribution. The emphasis on the distribution effects does not mean that overall expansion coefficients should or would be ignored. In fact, if we expect to remain in business long in impact analysis, they cannot be ignored. As professional economists, we should not ignore the differential impacts of resource programs among people or resource owners, in estimating net overall effects.

Political ramifications of government programs are a major aspect of impact analysis. While the distribution of economic effects among broad classes of resources—land, labor, and capital—has political significance, looking at the functional distribution is not a straightforward way to ascertain distribution of effects among interest groups or people. Thus, the Baton Rouge authors who emphasized the influence of asset fixity on distribution impact using production function analysis seemed to be approaching the problem obliquely. Noneconomists do not readily understand economists' concern for the distribution of program effects among classes of resources.

DIMENSIONS OF GENERALITY

The third point I want to discuss is the various dimensions of generality and my view on the more important dimension in river basin planning and Resource Conservation and Development (RC&D) work. At Baton Rouge, Albert Green discussed ways of developing input-output coefficients for smaller subareas from secondary information. The implication was that the national input-output model supplemented with other secondary data provided sufficient information to make inferences about the economic structure of small subareas, such as counties. Furthermore, the relationships between the national economic structure and subarea structures could be programed for computer application. Again, the implication was that with sufficient time and money, structural coefficients could be developed for each county in the United States. This broad geographic coverage is one dimension of generality.

The other dimension was suggested by two papers in the conceptual category on the structuring of a simulation model for a regional economy. These papers were written by L.M. Hartman and Melvin Skold. Hartman's model, the more general of the two, suggested the use of a linear programing model to depict the agricultural sector, an input-output model to depict the general structure of the economy, and functional relationships for the supply and demand of the more important primary input factors. These were to be linked in a system with automatic feedbacks. The dimension of generality here is not so much one of geographic generality as it is of comprehensiveness within a single geographic area. The ultimate goal is to estimate as many of the direct and indirect economic effects of government programs as possible or desired.

For the following pragmatic reasons, it is my view that geographic generality is a more important dimension for study of natural resource programs by the Federal Government than the dimension of comprehensiveness suggested by the papers on simulation. It must be understood, however, that my views are based upon considerations of national policy, an orientation that may differ from that of the Baton Rouge workshop.

First, the Federal Government should have a consistent approach to the study of aggregate effects of national policies, whether these effects are felt locally or nationally. Consistent measurements of the effects of government programs from a local, regional, and national viewpoint are necessary to put government policies into perspective in terms of the broad goals of national economic efficiency and regional economic development.

Second, geographic generality is consistent with the concept of framework plans for water resource regions now being developed. Translation of food and fiber demands into demands for resource development by use of a least cost efficiency model has permitted estimation of primary impacts of alternative resource development plans in regions of various sizes and complexity. Use of an interindustry model with varying levels of details to examine broad primary and secondary economic impacts could complement the primary impact evaluations made by using the efficiency model.

Third, the levels of detail in interindustry models can be modified substantially to fit the level of accuracy desired, the data at hand, our capabilities, and the budget. The continuum runs from the simple basic-service industry delineation to the comprehensive Leontief model employing primary data inputs. This suggests that immediate payoff can be obtained by incorporating base-service ratios into ongoing river basin and RC&D projects, and that as experience and money grow, more complete models can be developed. These more complete models may include simulation models such as suggested by Strohbehn's paper for the present symposium.

Fourth, models developed with emphasis on the geographic dimension of generality would be useful for analyzing impacts of many types of local, State, and Federal Government policies, in addition to estimating effects of resource development programs. Use of these models could broaden the support for this type of work.

THEORIES OF REGIONAL GROWTH

The final lesson, explicitly enunciated by Dr. Wilbur Maki, could be the most important one emanating from the Baton Rouge workshop. His admonition that various regional studies should be rationalized in the context of a general theory of regional growth is particularly appropriate in light of the previously suggested specific impact concepts. He reiterated the idea that a region advances through several stages of growth. A region is first a debtor paying for its net import surplus from capital imports. As investment capital grows, the region matures into an exporter, first of goods and then of capital in the form of loans. Gradually, investment opportunities within the region diminish to the point that the region completes one cycle which may or may not be repeated, depending on the institutional structure of the region and its ability to develop more investment opportunities.

Maki's point was that the export-base theory and the investment stimulated growth theory could both be rationalized in this more general "stage-of-regional-growth" theory. Furthermore, he felt a unifying fundamental theory was more important than the actual numbers that might be generated from growth models.

I believe this concept is vital in our work on impacts of natural resource programs. It is evident that we cannot measure all of the many different economic effects of government programs. Therefore, it is important that we recognize which type of impact we consider important enough to receive most of our attention. It is important that we explain to others, both economists and noneconomists, the major implications of the effects we are measuring explicitly and how these effects fit into a general theory of economic development.

The sometimes competitive relationship between the broad goals of resource development—regional growth and national efficiency—is the source of many of the conflicts of interest in river basin development. The Economic Research Service, with its orientation toward national efficiency aspects of resource development, has taken the brunt of the arguments many times. This is not necessary if economic impacts of resource development are cast in a general theory of economic development, as suggested by Maki.

This general theory of economic development should apply to various sized political entities such as the State, region, or Nation, depending on assumptions about key variables, such as final demand. If the techniques used to measure impacts are adaptable, a broad range of impact estimates can be given, depending on assumptions about the relative importance of regional growth vs. national efficiency. As planners, we are required to take a stand on the appropriate relationship between viewpoints, but as economists we need only provide economic information about the impacts of various alternatives with respect to assumptions and viewpoints.

III. SELECTED PRACTICES OF AGENCIES

THE ROLE OF SECONDARY EFFECTS IN PROJECT FORMULATION JUSTIFICATION AND EVALUATION FOR THE APPALACHIAN WATER RESOURCES SURVEY

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The Appalachian Regional Development Act of 1965 (Sec. 206 of PL 89-4) required the Water Resources Survey to prepare a comprehensive plan of development that would increase the production of goods and services within Appalachia, within a framework of efficiency. The presence of a depressed area, characterized by persistent long-term unemployment and underemployment within a national economy exhibiting high employment, raises a question as to the realism of some assumptions about mobility contained in the static efficiency model. Under conditions of unemployment, agreement exists in the literature with respect to the presence of secondary benefits from both the regional and national viewpoints and a divergence between monetary and total economic costs.

The purpose of this paper is to present the proposed methods of estimating regional and national effects of water resource projects in Appalachia. Some principles or viewpoints underlying the approach taken by the Appalachian Water Resource Survey in its development of proposed methods were as follows:

(1) With the growth in complexity of the economic life of the Nation and the regions, secondary economic effects of resource development will be increasingly important in the shaping of growth patterns.

(2) The utility of the traditional benefit-cost ratio will diminish, and the need will grow for a number of measurements to reflect different dimensions of national and regional benefits and costs, and objectives and goals. The indices of performance for future resource development should not only reflect national as compared with regional gains, but should also distinguish between economic gains from redistribution of income and those from increases in efficiency and improvements in the quality of the environment.

(3) Project effects may be measured at a number of points. When the effects are measured in the hands of the initial users, the benefits are limited to user or primary benefits. But if the stream of benefits is measured after the benefits have entered into second, third, and fourth hands, expansion effects will be included. These expansion effects, when properly estimated, include all the benefits up to the point of measurement, primary as well as secondary.

(4) In all resource planning efforts, emphasis should be on national, regional, and local opportunities, and on potentials and means of their realization, rather than on an estimation of "needs" based on established present circumstances.

MEASUREMENT OF EXPANSION EFFECTS

The first tools of analysis used in measuring expansion effects were benchmark projections fitted to available land. These projections reflect a normative goal, in that attainment of certain levels of income, population, and employment for the Appalachian region implies that the region, by the year 2020, would approach the normal economic performance experienced by the Nation. Benchmark projections were prepared for every economic region of Appalachia. These projections aid planners in gaining insight into area or regional possibilities to accommodate indicated levels of economic activity. They have also been modified as

planning proceeded to reflect constraints associated with land, transportation, labor force, and other factors required for economic development.

IDENTIFICATION OF DEVELOPMENTAL POTENTIAL

An important output of this benchmark analysis is a general inventory, by economic area, of land suitable for industrial and manufacturing development. The inventory includes an estimate of the amount of land with developable slopes, access available or potentially available, and location within reasonable distance of urban centers. One of the important conclusions from this inventory is that there is really sufficient land, if proper land use management and controls are applied, to support any likely level of economic development for the greatest portion of Appalachia.

Another potential tool for the purpose of identifying developmental potentials was the input-output system, completed under contract for the Office of Appalachian Studies, Corps of Engineers. This system covers three large subregions of Appalachia—the northern, central, and southern regions. This special regionally oriented input-output analysis permits analysis of the input requirements of industry located in Appalachia. When used in conjunction with future projections, it can indicate the kind of industrial inputs that may, at the present time, be imported but under an enhanced economic situation. Input-output analysis also provides a way to develop the multiplier effects of different economic sectors. One of the facts revealed by input-output analysis is that the employment multipliers, which were developed in another study, appear to be confirmed.

Several other tools and techniques are also utilized in this planning process. The analytic procedure of using locational quotients was adopted by several of the district offices in determining the occurrence of manufacturing and other activity in their economic regions. The procedure has many merits in that it displays the industrial sector's importance and shifts over a period of time. One of the most productive devices for identification of developmental potential has been the land use capability approach, demonstrated in the Upper Licking Report. The utilization of all the above-mentioned economic tools with a land use capability analysis provides a visual basis for making some rational judgments about the developmental potential of any area.

Expenditures by users of recreation facilities have been a source of opportunity for increasing the income of Appalachians. Most water resource developments have experienced very heavy use by water recreationists, and there is a significant level of income generated when an adequate level of recreation facility investment is provided.

Measurement of Expansion Benefits

Developmental expansion benefits have been calculated through the use of three general approaches or a combination thereof: (1) Land use and capability studies, (2) income and employment multipliers, and (3) allocation to water projects of difference between normal growth and stimulated growth.

The most common method of calculating expansion benefits was that developed for the Upper Licking River. In this procedure, a dual approach used (1) a land use study to determine capacity of the land to support economic growth, and (2) an economic analysis to project future growth possibilities in the project area.

In the Upper Licking Report, a sketch plan was prepared, and in conjunction with analysis of economic base data, estimates of employment income and investments were drawn directly from assumed implementation of the plan.[1/]

The sequence of the research tasks was as follows:

(1) The physical, economic, and social characteristics of the area were calculated in terms of the requirements for development of the downstream flood plain.

(2) The area from which the labor force is to be drawn was identified and the labor force was evaluated in terms of present employment, unemployment, underemployment, and skill availability. Local vocational training facilities were analyzed in terms of capacity and mix of available programs.

[1/] For details, see Spindletop Research, Expansion Benefits Analysis for the Salyersville-Royalton Area Pilot Project, prepared for the Office of Appalachian Studies, Corps of Engineers, Mar. 1967.

(3) The course of industrial development of the Salyersville area was estimated by:

(a) Developing a list of the 63 industries most likely to locate in the study area. These industries were selected from existing industrial location studies by Spindletop Research, Fantus, and others and identified by 4-digit Standard Industrial Classification (SIC) category. These categories were grouped into 2-digit SIC classes.

(b) Using Office of Business Economics (OBE) and Arthur D. Little (Ohio River Basin Study) economic studies as a framework for disaggregating growth for the project area. The disaggregation procedure reflected the influence of land use capabilities (including labor, prices, and market possibilities), the possible and probable industry mix implied by OBE and Arthur D. Little projections, and analysis of the share of the laborshed's growth possibilities. These factors also reflect initial basis in timber resources, the initial probable pentration of the apparel industry, the fact of the food deficit position of eastern Kentucky in general, a tendency toward metal fabricating, and increased industrial skills over time.

(4) Income estimates were developed to permit calculation of both regional and national expansion benefits. To calculate regional expansion benefits, it was necessary to estimate how much of the labor force for employment in new investment would have to be imported. This estimate, in turn, required estimates of the skill levels of the local work force. It was assumed that all skilled and managerial talent would be imported up to 1980 and that, thereafter, only manufacturing management would be imported. Increasing productivity was recognized implicitly in the employment and value-of-output projections of OBE and Arthur D. Little.

The bridge to service and commercial employment was built by applying an employment multiplier of 0.74 to projected manufacturing employment. This factor was derived from reports of investigation of these relationships by the University of Kentucky's Bureau of Business Research. Service employment was similarly broken down by skill levels and wage rates to determine wages paid to employees from indigenous sources. These rates were applied to projected employment by skill level to yield the total wage bill. Benefits reported showed total wages for manufacturing and service employment by skill level for each decade to the year 2020.

(5) A sketch plan for the flood-free land was developed to provide a basis for making preliminary cost estimates. This plan showed the proposed location of plant sites, commercial and service areas, residential areas, and recreational areas; the location of highways, rail facilities, and access roads for industrial sites; and tentative locations of utilities and other municipal facilities necessary to make proper use of the industrial sites. From the information obtained, it was possible to calculate the estimated incremental public and private investments required to complete the 50-year projected development of the area.

Cost estimates for calculating net expansion benefits were reported showing public and private non-Federal investment and Federal investment by decade to the year 2020. Public non-Federal investment included cost of schools, recreation facilities, fire protection facilities, roads, and utility systems. Private investment included costs of residential, commercial, and industrial development and quasi-public utilities investment. Federal investments included the Federal share of projected costs and related project activity through grant-in-aid programs.

The salary and wages generated as a result of the area development plan then were assigned to the national and regional accounts. The regional account reflected all of the increased wages and salaries, while the national account reflected only the wages of persons who would be expected to be underemployed and unemployed without the project. In developing the latter account, rates of unemployment, mobility, outmigration, participation in training programs, and other factors were considered. In the case of the Upper

Licking River, all of the wages of the locally employed were attributed to the national account during the first year and then were scaled down to 10 percent, 40 years in the future. In most other areas, only about 10 to 20 percent of the wages of the locally employed were assigned in the first year, and then were scaled down to zero in 10 to 20 years.

In addition to salaries and wages, the regional account also was credited with a return on investment factor computed annually as 10 percent of the industrial and commercial investment in effect in each year, discounted to 1970 at an interest rate of 3 1/8 percent. The replacement investments necessitated by normal wear or obsolescence were not used in this determination.

The Baltimore and Charleston Districts estimated development expansion benefits through a procedure that provided approximate expansion effects. The results were used to demonstrate relative magnitude rather than precise benefit data. This method is suitable only if expansion effects do not affect the site and scope of the projects. Therefore, this method has not been fully accepted by the Appalachian Water Resources Survey and the Office of the Chief of Engineers.

Expansion benefits from recreation have generally been made by a method based on the following average local expenditures per visitor, conservatively derived from numerous studies and reports:

One-way distance of travel	Daily expenditure per visitor
0-25 miles	$0.50
26-50 miles	1.00
51-75 miles	2.00
more than 76 miles	4.00

The procedure for obtaining expansion benefits is as follows:

(1) Obtain total visitor-days per year from the Department of the Interior's Bureau of Outdoor Recreation (BOR), based on the scale of recreation development of the project.

(2) Estimate percentages of total visitors who will travel various distances in visiting project. BOR will assist in these estimates.

(3) Multiply numbers of visitors by expected expenditures and add. The resultant sum represents an estimate of annual local expenditures.

(4) Multiply this sum by the county multiplier developed by Robert Nathan and Associates to obtain total expansion benefits from recreation.[2]

Adjusting for Secondary Costs

The gross expansion benefits should be offset by any losses (secondary costs), including income streams foregone, that would occur because of the program or project. An adjustment should be made in project studies to reflect induced losses. One procedure reflects incomes that could be reasonably expected on the projected land use, in the absence of the project, discounted and converted to average annual equivalent values. National income losses are accounted for by an adjustment for loss of land productivity times market values of land and improvements plus personal income losses if the project will increase unemployment levels. Regional income losses require an estimate of personal incomes generated by current and future land use, including multiplier effects, without the project. These procedures cover a considerable amount of secondary costs. A number of individual situations have been evaluated. For example, in one case, a reservoir would decrease access to certain forest reserves and, therefore, decrease their value since value and productivity are, to a great extent, dependent on access.

REDISTRIBUTION OF INCOME

Redistribution of income occurs when less than complete reimbursement of benefits from a public investment is required. The framework of analysis developed by Maass and others in "Design of Water-Resource Systems" portrays these benefits as a secondary objective in addition to an augmentation of national income.[3] The Appalachian Water Resource Survey utilized this idea in the context of pursuing plans that would, through the "consumer surplus" inherent in less than complete reimbursement, encourage the private

[2] Robert R. Nathan Associates, Inc., Recreation as an Industry, 1966, pp. 123-131.

[3] Maass, Arthur, et al., Design of Water-Resource Systems: New Techniques for Relating Economic Objectives, Engineering Analysis, and Governmental Planning, Harvard University Press, Cambridge, 1962.

sector to adopt investment decisions that would be consistent with the goals of the Appalachian Regional Development Act of 1965.

While these "consumer surplus" benefits are not portrayed in a special account, they are displayed in one of the lesser indices of performance as additional information. The benefits are measured as a difference between user benefits, referring to the Appalachian region, and the reimbursement required from the region.

ENVIRONMENTAL QUALITY

Various aspects of environmental quality are affected by water resource development. The Appalachian Water Resources Survey has sought the kind of projects that would improve and enhance the environment by, for example, improving water quality by reducing acid mine waste load; reclaiming mined areas for public use; increasing dissolved oxygen resulting from provision of dilution water to accompany adequate treatment; and reducing bacterial contamination by dilution and treatment. Aesthetic management of project areas is also sought.

Water resource projects can improve fish and wildlife habitat through the increase in dissolved oxygen and improved stream flow characteristics on both high and low flow, and through the dilution of bacterial and acid mine contamination. Fish and wildlife habitat can be improved by management and improvement of public use areas and management of certain project lands for fish and wildlife enhancement. Environmental gains are also present in the increase in opportunities for general recreation use. The Appalachian landscape is, in many areas, blighted by unwise and uneconomic land use; the aesthetics of the area can be improved by water resource projects that are of pleasing design and that are involved in stream clearance, mine restoration, and land reclamation.

Many aspects of environmental enhancement are intangible, which makes measurement of benefits complicated. Normally, user benefit calculations estimate the value to users of improvement of water quality, of improvement in fish and wildlife habitat, and in the increase in opportunity for general recreation use, either directly or indirectly, in terms of alternative costs. But benefits are very difficult to assign to the aesthetic improvement of project areas and project purposes.

In addition to user gains, expansion benefits also result from the enhancement of environment. In the sections of Appalachia characterized by serious environmental quality problems, such as the older coal fields and the central Appalachian area, improvement of the environment is a first step to attract economic activity to the area. Therefore, in some regions, project recommendations emphasize environmental improvement as a strategic approach to regional development.

There are some special problems in measuring the benefits from programs that would reduce or control polluted drainage from mines and restore the terrain disturbed by deep and surface mining. Aesthetic considerations are dominant in the plan of benefits from such programs and account for the special problems.

Even among the so-called measurable benefits, there is reason to question the accuracy and comprehensiveness of existing figures. It is well known that acid mine drainage causes damage to water craft and all manmade facilities in or using polluted water through encrustations and corrosive actions. Cost, and therefore benefit, figures are available from past studies, but they are admittedly incomplete. It is technologically feasible to conduct a thorough and relatively accurate survey to measure the direct costs to industry and the public resulting from the reduced life of the physical facilities using and in contact with polluted water. However, the cost and time involved in such a study have made it prohibitive.

The Department of the Interior's Bureau of Sport Fisheries and Wildlife has developed a technique for measuring benefits to a community having clean, fishable streams. The number of man-days of fishing an area could expect is estimated, and an anticipated expenditure of $5 per fisherman per day is allocated to the local community. The estimates of gains for the local community resulting from expenditures by fishermen attracted to the area by clean streams is probably fairly accurate and substantial, but the net gains for the nation may be quite limited.

Measurement of benefits becomes much more difficult when one considers the general health of the people living in the vicinity of coal mines or along the polluted streams. Knowledge of the detrimental aspects of mine drainage on health is limited, but they are

probably far less than those created by dumping of municipal and industrial wastes into the streams, or from fires in old mines and refuse piles. Dissolved solids from mining activities are known to cause a diarrheic condition which undoubtedly lessens the strength and initiative of the afflicted populace.

An even more difficult effect to measure is the aesthetic loss associated with discolored streams and blighted countryside caused by mining activities. What is the loss to society due to the degradation of mental health of the local populace and persons traveling through the region? What is the economic loss to the local economy when potential tourists and industries avoid the area? Our present state of knowledge does not permit complete and accurate accounting of these losses.

EVALUATION OF SECONDARY BENEFITS FROM THE ACCELERATED WATERSHED PROGRAM IN APPALACHIA

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The purpose of this paper is to outline the accelerated watershed and land treatment program in Appalachia and to discuss the methodology being used to estimate secondary benefits from installation and operation of the proposed structural and land treatment improvements. The relationships between the accelerated watershed program and the regular P.L. 566 watersheds and between the U.S. Department of Agriculture and Corps of Engineers programs also are discussed, from the standpoint of evaluation of secondary benefits. No attempt is made to develop an "ideal" system of measurement of secondary benefits in this paper.

USDA PARTICIPATION IN THE APPALACHIAN WATER SURVEY

Secretary's Memorandum No. 1579, dated July 8, 1965, stated that "it is the policy of this Department to utilize all of its relevant program activities to help in developing the full economic and social potential of the Appalachian region." In the same memorandum, a USDA Committee for Appalachian Development was established with a member from each agency in the Department.

USDA participation in the Appalachian Water Resources Survey is based on the Plan of Work developed by the Soil Conservation Service, the Forest Service, and the Economic Research Service in March 1966, under the leadership of SCS. As stated in the plan, "the primary overall objective is to facilitate the coordinated and orderly conservation, development, use and management of the water and related land resources of the Region. This is to be done in such a way as to provide a means of expanding economic goods and services. . .The comprehensive plan (for the use of water and related land resources) would stimulate economic growth, enhance the welfare of the people, and constitute an integral and harmonious component of the economic development program of the Appalachian Region."[1/]

A major element in the survey was the selection and study of approximately 100 upstream watersheds with "known water resource problems and local interest in their solution." [2/] The selection was guided by the location of the problem area and its potential contribution toward the economic growth of the region. It may be helpful at this point to outline the actual procedures used in selecting the 100 watersheds which constitute the accelerated upstream program. SCS watershed planning parties in all of the States into which the region extends were asked to select watersheds that were not currently being considered under P.L. 566, were not recommended as a part of any comprehensive river basin plan, were dispersed throughout the region, and would contribute to the overall economic growth and development of the Region. In New York, Pennsylvania, Kentucky, West Virginia, Tennessee, and Ohio, many potential watershed areas were already preempted by the Ohio comprehensive river basin survey. The 100 watersheds tend to be marginal in terms of benefit-cost ratios for flood protection and other functions.

1/ USDA Plan of Work, Appalachian Water Resource Survey, 1966, p. 14.

2/ Ibid, p. 15. During the course of the Survey, additional watershed projects were studied. As a result, a total of 198 projects were recommended for authorization by the Department. (See Appendix A to the Report of the Appalachian Water Resources Survey.) However, the discussion in this paper is limited to the original 100 projects.

PRESENT TREATMENT OF SECONDARY BENEFITS IN UPSTREAM WATERSHED PROJECTS

Secondary benefits are defined in the SCS Economics Guide for Watershed Protection and Flood Prevention as "the values added over and above the immediate products or services of the project as a result of activities 'stemming from' or 'induced by' the project."[3/] The distinction between the two types of activities is based on a breakdown of project-related inputs and outputs. The Economics Guide discusses "stemming-from" benefits under the heading of "increased production," and "induced-by" benefits under "added purchases." Activities stemming from a project include increased production of goods and services resulting from the project. Benefits stemming from projects are illustrated in the Economics Guide by the increased returns to commercial truckers from hauling the extra grain produced on lands afforded protection by a watershed project. Benefits induced by a watershed project result from the supplying of additional inputs required to produce the higher levels of output associated with the project. These are exemplified in the Economics Guide by the increased income of fertilizer and seed dealers from selling additional fertilizer and seed to farmers in the project area. Further examples are provided in discussing secondary benefits of the recreation function of upstream watersheds. These include the increased output of goods and services from hotels, grocery stores, service stations, and other business establishments dealing with visitors to recreation areas.

The Economics Guide refers to zones of influence of watershed projects in estimating secondary effects. In general, the Guide is rather restrictive in its allowance of benefits beyond the immediate project area: "From a local viewpoint, secondary benefits are quite significant when the increased products are processed and marketed within the project area. This economic effect lessens as one broadens the analysis to a State or regional viewpoint and becomes almost nil from a national viewpoint. Under. . .the assumption of a continuously expanding economy, it would be expected that other uses would be available for the resources required by the project, and purchases made by people of the project area would bid these production goods away from the other uses in the economy. For these reasons, secondary benefits from a national viewpoint are not considered pertinent to the economic evaluation of P.L. 566 projects."[4/] This view of national secondary benefits is in sharp contrast to the procedures developed for the Appalachia program. The difference in procedures will be discussed in greater detail later in this paper.

The approach used in estimating secondary benefits involves a comparison of the local economy with and without the project. No secondary benefits may be claimed unless "it can be shown that there is an increase in net income in secondary activities as a result of the project. . ."[5/] The Economics Guide points out that a thorough analysis of the economy would require considerable time and effort. As a substitute for this type of analysis, the Guide recommends that local secondary benefits be estimated at 10 percent of the direct primary benefits "stemming from" the project plus 10 percent of "the increased costs that primary producers will incur in connection with increased or sustained production."[6/] Direct primary benefits include benefits from reduction of flooding and erosion damages, more intensive land use, changed land use, agricultural water management, recreation, fish and wildlife, and municipal and industrial water supply.

REDEVELOPMENT BENEFITS

Secondary benefits and redevelopment benefits are closely related. The latter are claimed because of the possibility that installation and operation of projects will increase economic activity in areas of substantial and persistent unemployment or underemployment as defined in the Area Redevelopment Act of 1961. Such areas were seen as requiring outside assistance to achieve higher levels of economic activity, and regular P.L. 566 watershed projects in these areas are credited with redevelopment benefits because of the assistance that they provide. Both the construction and operation of the project are considered in estimating redevelopment benefits. The period in which benefits are expected to accrue is limited by the economic outlook for the project area. Unemployment or underemployment that is expected to persist over a long period of time will justify greater benefits than could be claimed where the depressed conditions are only temporary.

3/ Soil Conservation Service, Economics Guide for Watershed Protection and Flood Prevention, U.S. Dept. of Agr., Mar. 1964, ch. 11, p. 2.

4/ Ibid.

5/ Ibid.

6/ Ibid., p. 3.

The close relationship between redevelopment and certain secondary benefits can be inferred from the Economics Guide's caution that "care should be taken to avoid possible duplication of benefits from other sources. Redevelopment benefits stemming from new industry may duplicate primary or secondary benefits from providing a municipal water supply. Another possibility of duplication might arise if local agricultural products were used as raw materials for processing as a result of plant expansion. If redevelopment benefits were claimed from this source they might duplicate benefits from changed use of agricultural land."[7]

USDA WATERSHED PROJECTS IN APPALACHIA

A brief description of the accelerated watershed program in Appalachia and its relationship to the regular watershed program will place it in perspective for the discussion of new provisions concerning the evaluation of secondary impacts in the 100 special Appalachian watersheds. There are some 300 upstream watershed projects in Appalachia in addition to the 100 special projects. These include the pilot watersheds started in 1954 and 1955, the regular P.L. 566 projects, and the P.L. 566 projects studied in connection with the comprehensive river basin surveys. Thus there is already a considerable program of upstream water resource development in the Appalachian region.

The 100 special watersheds studies in the Appalachian Water Resource Survey are dispersed through all of the States of Appalachia except Mississippi, which was added to the region by a special legislative act after the beginning of the survey. The 596 structures in the 100 projects control nearly 5,000 square miles of drainage area. The structures would impound about 1.5 million acre-feet of water, of which 1.1 million acre-feet would be allocated to flood prevention. The volume of water stored for recreation purposes is next most important, with 298,000 acre-feet of storage capacity. Water stored for municipal and industrial uses and water quality control accounts for 133,000 acre-feet. Only 3,500 acre-feet are allocated to irrigation. That figure is likely to be a conservative estimate of potential for irrigation, however. Irrigation was specified as a purpose in only four projects, probably because of lack of interest in irrigation among local projects proponents. An additional 1.1 million acre-feet of storage could be provided for other beneficial uses.

Estimated flood damages average $5.3 million annually in the 100 special watershed areas. Damages to residential and commercial property are the most important component of the estimate. Less than one-third of the damages are inflicted on agriculture, because of the high proportion of nonfarm land in the Appalachian region. Implementation of the special watershed plans would reduce damages by $3.9 million, or approximately 74 percent.

Dollar benefits for the 100 special watersheds are estimated at $21.4 million annually, of which about 18 percent are from reduction of flood damages, and 54 percent from recreation.[8] Nearly one-fifth of the estimated benefits are secondary and redevelopment benefits.

PROCEDURES USED IN EVALUATING SECONDARY AND REDEVELOPMENT BENEFITS IN THE ACCELERATED WATERSHED PROGRAM

Evaluation of secondary and redevelopment benefits in the 100 special watersheds differed in two important respects from evaluations in the regular watershed programs. First, redevelopment benefits were assumed to be present in all 100 projects.[9] They were based on 30 percent of construction costs and 50 percent of annual operation and maintenance costs. These benefits and those for employment stemming from use of the project improvements were computed on a descending scale over a 25-year period. The use of the 25-year period for calculation does not imply that unemployment will be a serious longrun problem for the Appalachian region.

The second point of difference between the 100 special watersheds and those of the regular P.L. 566 program is the evaluation of national secondary benefits. National secondary benefits have not been considered in the watershed program previously, but for the 100 special watersheds they were included in the benefit-cost ratio.

[7] Ibid., Ch. 12, p. 4.

[8] Some modification in the number of watersheds and the amount of benefits is expected in the USDA study. However, the methodology is not expected to be changed.

[9] Soil Conservation Service, Appalachia Memorandum No. 2, Watershed Protection Program in the Appalachia Region, U.S. Dept. Agr., July 1, 1965.

Watershed planners were also urged to consider intangible benefits "which are compatible with the objective of the Appalachian Regional Development Act," and to "emphasize fully the opportunitities for development which would be relinquished by failure to install the project." [10] Intangible benefits considered include scenic improvements due to stabilization of eroding areas and reduction of air pollution.

USE OF "EXPANSION BENEFITS"

To be consistent with Corps of Engineers procedures as discussed by Robert Harrison in the preceding paper, "expansion benefits" were estimated for some of the 100 special upstream watersheds where changes in land use might occur. "Expansion benefits" are quite closely related to secondary and redevelopment benefits because they include benefits induced by and stemming from project installation and operation.

Because of the stated goals of the Appalachian Water Resource Survey to assist in the economic development of the region, special efforts were made by SCS to locate upstream watershed projects in areas where the stored water and reduced flood hazard might contribute to increases in nonfarm economic activity. Such efforts were concentrated in the 100 special watersheds, and no consideration was given to developing nonfarm economic activity in the other watershed areas of the region.

Projecting economic activity in an area the size of a small watershed is extremely hazardous. In general, such areas are smaller than the project areas being developed by the Corps of Engineers, and a correspondingly larger risk is involved in projections of economic activity. Field surveys were made by SCS to determine whether any of the 100 special watershed project areas appeared to have a potential for future conversion from less intensive uses to commercial, industrial, and residential activity.

The field check revealed that most of the special watershed projects could not be expected to contribute directly to industrial, commercial, or residential development. Factors considered in the field check of watershed projects included degree of flood protection, size of area receiving flood protection, slope of land, access to highways and railroads, availability of labor for nonfarm jobs, and nearness to urban centers. Project areas were rated high, medium, or low from the standpoint of potential for nonfarm development, and only those 17 areas that rated high were considered further.

COMPUTATION OF INDUCED INVESTMENT, EMPLOYMENT, AND INCOME

Computation of induced investment in the 17 watersheds with high potential for nonfarm development followed much the same procedures as those used by the Corps of Engineers and Spindletop Research, Inc., in the Salyersville (Upper Licking Basin) project; however, calculations of induced investment per acre were less detailed. The Salyersville project method assumed that a wide variety of industries would be attracted to the area. The induced investment per acre was estimated by averaging the expected investment for all industries. The SCS estimate of investment is based on a smaller number of industries but is quite close in dollar terms to the Salyersville project area. The induced investment was amortized over the life of the project and a multiplier applied to the amortized value to determine the impact of induced investment. The multiplier was taken from the Nathan Report for the county in which the project area is located. [11]

Industrial employment was estimated by multiplying the acreage of industrial land by the number of employees per acre assumed in the Salyersville project area. Further increases in employment were assumed to occur in the commercial and service sectors of the economy in response to increased industrial activity. Increases in employment were attributed largely to local labor. Only 15 percent of the required labor would be imported.

Income increases resulting from the growth in investment and employment were estimated from data accumulated in the Salyersville project. Wages or salaries per employee, based on a distribution of skill levels as reported in that project, were used to determine the extent of increases in income.

Expansion of income and employment due to recreational development was estimated in much the same manner as in the Salyersville project. Expenditures

[10] Ibid.

[11] Robert R. Nathan Associates, Inc., and Resource Planning Associates, Recreation as an Industry, Washington, D.C., Dec. 1966.

per visitor-day were assumed to range from 50 cents to $3, based on distance traveled to the recreation area. The amount of expansion benefits claimed for recreation was relatively small, because it was assumed that 80 percent of the visitors would originate in areas near the project and no expansion benefits would be claimed for them. To arrive at expansion benefits, the remaining visitor expenditures were multiplied by the "Nathan multiplier" for the county in which the development was located.

ALLOCATION OF PROJECT BENEFITS TO NATIONAL AND REGIONAL ACCOUNTS

Project benefits were allocated to national and regional accounts on the basis of Corps of Engineers procedures. National benefits were assumed to occur when unemployed or underemployed resources were put to work. The portion of redevelopment benefits due to construction were credited to the national account, while the portion based on operation and maintenance was divided between the national and regional accounts in proportion to the amounts of semiskilled and unskilled labor utilized in the projects.

COMPARISON OF "CONVENTIONAL" AND "EXPANDED" BENEFITS

As mentioned earlier in this paper, project benefits measured by conventional SCS techniques were estimated at $21.4 million. Expansion benefits were greater than the original or primary benefits, resulting in "total" benefits of $46.6 million. It is obvious that an increase of benefits by this magnitude makes the program more attractive as a public investment. General acceptance of the expansion benefit concept would have real implications for water and related land resource development.

CURRENT PROCEDURES USED IN EVALUATING RESOURCE CONSERVATION AND DEVELOPMENT PROJECTS

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The major purposes of this paper are to present an overview of the operation of the Resource Conservation and Development (RC&D) program and to discuss evaluation procedures currently being used. The RC&D program is administered by the Soil Conservation Service (SCS). SCS is not required by law to provide a benefit-cost ratio for RC&D activities. The exceptions to this rule, however, are individual project measures included within the project activities; for example, watershed developments which always require economic justification regardless of the broader programs of which they are a part.

THE RC&D CONCEPT

Although an RC&D project has a number of functions, its working definition is as follows: "A Resource Conservation and Development Project is a locally initiated and sponsored activity whose purpose is to expand the economic opportunities for the people of an area by developing and carrying out a plan of action for the orderly conservation, improvement, development, and wise use of their natural resources."[1/] Peculiar resource problems and representative conditions may exert strong influence on an area's selection.

The major thrust of RC&D is toward the improved management of natural resources for the improvement of local economic conditions. The RC&D program represents a movement from consideration of soil, water, and timber to consideration of all aspects of natural resources including natural beauty, fish and wildlife, and a comprehensive view of the natural environment. It represents a change from a focus strictly on agriculture to one on all segments of the economy of the project area.

[1/] Soil Conservation Service, Resource Conservation and Development Project's Handbook, U.S. Dept. of Agr., Aug. 1965, p. 1.

LEGAL BASIS AND OPERATING PROCEDURES

The basis of the RC&D program lies in Public Law 87-703, the Food and Agriculture Act of 1962.[2/] Section 102 of this Act authorizes the Secretary of Agriculture "to cooperate with Federal, State, Territorial and other public agencies in developing plans for a program of land conservation and land utilization, to assist in carrying out such plans..." Under the 1962 Act, the Department of Agriculture was given authority to cost-share on structures having land and water conservation aspects.

The Secretary has specified that agreements for cost-sharing and transition payments in a Cropland Conversion Program, as provided for in Secretary's Memorandum No. 1518, will be utilized to further the objectives of RC&D projects.[3/]

From this enabling legislation a program of resource development has grown that has as its driving force, locally interested citizens who organize to better the conditions of their communities by effective use and conservation of their resources.

Committees and Leadership

The local committees are composed of locally interested citizens who organize on the basis of resource problems and development needs. The project sponsors

[2/] Office of the Secretary, Resource Conservation and Development Projects, Secretary's Memorandum No. 1515, U.S. Dept. of Agr., Nov. 2, 1962.

[3/] Office of the Secretary, Development and Administration of Cropland and (Conversion) Programs under Section 101, Food and Agriculture Act. 1962, Secretary's Memorandum No. 1518, U.S. Dept. of Agr., Nov. 2, 1962.

are responsible for deciding upon measures to include or exclude from their project plan, appropriate sponsorship of project measures, resolving conflicts of interest, setting priorities and goals, and, finally, developing a practical plan of action that will lead to achievement of their project objectives.

RC&D Project Area

A project area has been defined as "all territory within the boundaries determined by project sponsors and described in their application for assistance."[4] This definition may be inimical to the selection of a sound economic base as territories frequently truncate and bisect functional economic areas. RC&D areas, to a degree, however, frequently encompass central growth nodes exemplified by regional or community trading centers

Problem Situations in Project Areas

RC&D project areas are diverse in terms of their geography, distribution, and types of resources. It would be misleading to classify all RC&D areas by means of a single characteristic. Some fairly common economic characteristics, however, have been found to recur with fairly high frequency. One of the most common is a general deteriorating condition in resource development that has been brought about in the wake of the decline or failure of local resource-based industries; for example, agriculture, mining, and forestry.

The deteriorating conditions that local and small community leaders have noted are related to declining business associated with sizable migrations and losses of purchasing power of areas, declining population and a shrinking tax base, high-cost enterprises and a loss of comparative advantage in interregional competition, migration of the younger labor force, and loss of community institutions having prized social value.

These conditions have caused local leaders to seek alternative ways of using their resources to make substitutions for the declining components of their economies.

The Project Plan

The project plan is the RC&D committee's concept of its aspirations; that is, a catalogue of its resources and an enumeration of expectations for development. The project plan has as its basis a sound economic inventory and appraisal of the resources contained within the limits of the project area. Again, however, it must be noted that proper selection must be used in delimiting a reasonably functional economic base that also must be well integrated into a regional economy. Without careful selection of an area, the conclusions and the emphasis placed on the appraisal of the project plan may be distorted or meaningless.

Project Measures

A project measure is a feature incorporated into the project plan that has been suggested as an improvement for the community. Implementing this measure should improve conditions in the community either from the standpoint of economic upgrading or of improving the general quality of living. Frequently, the selection of project measures reflects community interest or prejudice and therefore may not place special emphasis on actions that may have the greatest impetus for growth. In some RC&D areas, some selected measures have not been given the proper weighted priorities that would accurately reflect the predominant interests of the communities.

Project Coordinator

A key man in the RC&D project is the project coordinator. He is charged with the responsibility for stimulating, coordinating, and facilitating the interests, goals, and program of the local RC&D committees. He serves as a link for all Federal and State programs which can be used to accomplish the measures proposed in the project plan.

METHODOLOGY FOR ESTIMATING ECONOMIC IMPACTS ASSOCIATED WITH RESOURCE DEVELOPMENT PROGRAMS

Inadequacies of Existing Methodologies

A thorough review of a number of methodologies in the literature for measuring economic impacts leads one to conclude that existing methods are inadequate, although not necessarily in a conceptual sense. Existing methods are believed to be deficient because of (1) lack of suitable secondary data and the expense of obtaining primary data; (2) difficulty of measuring income and

[4] Soil Conservation Service, op. cit.

employment effects of relatively small expenditures associated with local impact programs; and (3) the problem of accurately attributing local impacts independent of regional and national economic activity.

Elements of the ERS Methodology

As a result of these inadequacies, ERS responded to the increasing demand for measures of effectiveness for community development programs by formulating procedures for analyzing resource development. The objective of the method summarized below is to effectively estimate the economic impacts involved in the impact relationships associated with resource development.

The ERS methodology is comprised of two major components: (1) A categorical inventory of activities or measures planned by the community program, the refinement of which is an information system listing for each measure the estimated costs, duration of expenditures, breakdown of the respective cost components (such as labor, machinery, and materials), and associated man-years of employment required to construct or activate measures; and (2) a system of multipliers to be applied to the preceding overall cost estimates to derive impact estimates of the total income anticipated.

The information system is the heart of the methodology used to analyze economic impacts. It includes the expenditure, the project measures, the timing of their installation, and any changes in project plans—such as additions and deletions of measures, or changes in the design of measures. A continuous inventory of operaton and economic data is maintained for the community development program, the project at hand, and the individual project measures.

The ERS methodology traces expenditures linked with resource development and associates them with the economic impacts experienced at the local level. Analysis of these impacts aids in determining the economic relationships and interactions existing within the rural-urban balance.

A number of statistical and nonstatistical techniques are being used by the methodology system that relate to economic activity stimulated as a result of the establishment of RC&D projects. Not all features of the RC&D program have been evaluated, however, because many intangibles—such as the elimination of public "eyesores," preservation of natural beauty, and improvement in community spirit—defy quantification.[5/] Nor should it be assumed that the economic activity that has been generated by the RC&D program is due entirely to Federal funds being spent in the area. There is no magic in use of Federal funds without adaptation of these funds to local opportunities by local people.

Primary Economic Effects

Primary economic effects that are analyzed in community development programs closely relate to the association of income expenditure patterns and man-years of employment locked into these relationships. Estimation of project impacts is made directly; impacts for each project measure are traced, and estimation techniques are successively refined as experience and results from supplemental studies accumulate.

The methodology for evaluating RC&D programs previously discussed assists in analysis of primary and secondary economic effects. Analysis of primary income effects includes a complete inventory of the installations or measures established, scheduling of installations, sources of funds, construction costs by input factors, continuing expenditures associated with the measures, and types of employment created. Estimates are made for each project measure or group of similar measures, including the following: Scheduling of installations; imputing the continuing expenditure associated with the measure; and assessing general types of employment created.

Secondary Economic Effects

Secondary economic effects are largely related to income considerations and are primarily determined by applying multipliers to the expenditures associated with the measures.[6/] The multipliers are derived from gross county employment classes developed in special studies.

Expenditures in RC&D project areas will generate secondary income effects. Guidelines for estimating such income effects are being continuously developed. RC&D project areas, however, generally encompass one to

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[5/] Johnson, Hugh A., and Russell, Jesse R., Economics of Natural Beauty, U.S. Dept. of Agr., Econ. Res. Serv., Natural Resource Econ. Div., published paper presented at Annual Meeting, Soil Conservation Society of America, Des Moines, Iowa, Aug. 13-16, 1967.

[6/] This is in contrast to direct measurement of both primary income and primary employment effects.

several counties. This makes precise determinations of these income effects extremely difficult. There is a sizable variation in the complexity and vigor of the economies contained. These economies vary from the booming suburbs of Atlanta, Ga., and Eugene, Ore., to the generally less vigorous economies largely dependent on primary industries, such as in South Dakota and the upper Great Lakes.

Interim guidelines for selecting multipliers have recently been developed. They are based on the size of the county labor force, which reflects the relative complexity of the economy; that is, the larger the labor force, the more complex the economy. The more complex the economy, the less is the leakage in secondary rounds of expenditures from the county and the larger the income multiplier. [7] The table below presents relationships between county employment and applicable multipliers.

Selection of appropriate county multipliers within the above guidelines is determined by ERS economists on the basis of their knowledge of the areas involved. If the major trading area serving the county is centrally located, the income multipliers can be expected to be larger than average for its employment size class. If the trading areas are on the edge of or outside the county, the multipliers will probably be lower than average. The relative balance between economic sectors of the economy and other characteristics is also considered.

As was stated earlier, most RC&D projects include more than one county. While the income multiplier for five counties with 3,000 to 4,999 employment is not the equivalent of the multiplier for one county with 10,000 to 19,999 employment, the multicounty multiplier will ordinarily be expected to be larger than the multiplier for any single county. Therefore, as an interim guideline the upper range for the county in the largest employment class is used.

If the RC&D project has three counties, for example, with 3,000 4,000, and 12,000 employment, respectively, the income multiplier for the project area could be expected to fall into the range 2.0 to 2.2. Again, the selection depends on the evaluation by ERS economists based on analyses of local conditions.

[7] These average multipliers and ranges are based on multipliers developed for 375 Appalachian counties. Great diversity exists in Appalachia, and several counties are experiencing rapid growth. The Georgia project area referred to above is included in Appalachia. See Recreation as an Industry, A Report Prepared for the Appalachian Regional Commission, Robert R. Nathan Associates, Inc., Resource Planning Associates, Dec. 1966.

Average multiplier values and ranges, by county employment size classes

County employment size-class	Average multiplier	Probable range [1]
1,000 - 2,999	1.7	1.5 - 1.9
3,000 - 4,999	1.8	1.5 - 2.0
5,000 - 9,999	1.9	1.6 - 2.1
10,000 - 19,999	2.0	1.8 - 2.2
20,000 - 49,999	2.2	2.0 - 2.4
50,000 and over	2.2	2.0 - 2.5

[1] Based on data for 375 Appalachian counties, there is a probability of 70 percent, or 7 chances in 10, that individual county multipliers will be included within these ranges.

The overall total income generated is determined by all expenditures–RC&D and other Federal, State, and local, including loans–times the selected multiplier. The above procedure is interim and to be refined as information is accumulated from selected studies of installed project measures. Also, it is intended for use in estimating secondary income effects only.

Employment Effects–A Direct Function

Employment effects of RC&D projects are a subject for continued study. The sustaining employment effects, at least in the short run, are expected to be modest in comparison with immediate one-time employment effects in project areas. Furthermore, there is great variation among various project economies. In some project areas located in economically depressed regions, direct income increases will occur for employed workers in the service sector, where underemployment is prevalent. Because of this underemployment, there will be no increase in number of jobs, however. In more prosperous areas, where workers in service sectors are fully employed, additional income will require importing labor from other areas, or labor costs will become inflated.

The operation of the employment multiplier requires the presence of unemployed labor of suitable skills. The employment multiplier is an important

problem for investigation and one in which progress is expected in the future. At the present time, high priority is being given to incorporating other impact techniques in the methodology.

Methodology Dependent on Inputs from Many Sources

Information used in evaluating the RC&D program has included data from the Soil Conservation Service and State and local governments, including information on such items as improved community development and water use. These data have permitted evaluation of economic progress of certain selected RC&D areas using indices that relate to population, income, household data, retail sales, and sales activity. But the key indices currently being used to make "within" and "between" comparisons of RC&D project areas are: (1) increases in the area's total income, and (2) increases in man-years of employment. As stated previously, this evaluation procedure is concerned with determining primary and secondary income and employment effects.

UNRESOLVED ISSUES

The methodology that has been outlined has a number of limitations, several of which have already been described. The limitations arise largely because of the lack of answers to theoretical questions, although some very practical considerations are also involved. Some information gaps are discussed below.

The Nature of Economic Benefits to the Project Area

The economic benefits to a community are derived from those quantifiable features which can be translated into increased income and additional man-years of employment. There are wide information gaps, however, created by the lack of answers to key questions. The economic benefits relate to a number of significant variables, some of which are "masked" by the lack of answers to such questions as: What does this local community produce for the outside world? What is the community's comparative advantage to outside investors' capital in terms of production costs and services, and its relative position in terms of a broader regional and national economy?

(1) The RC&D "effect"—One of the most difficult problems encountered to date is that of attributing the degree of association of an RC&D "effect" to the economic activity generated or attributed to any given project measure. The rate of association of the RC&D effect to the total economic effect probably runs from nearly 100 percent in terms of some specific land resource-recreation measures to almost 0 for some measures involving industrial and service industries. It may be true that RC&D had a strong influence on bringing in a capital installation, but would it be true to say that without RC&D it would not have come? However, the problem has only been partially resolved by use of this simple question.

(2) The selection process in project location—RC&D project areas are fairly widely distributed throughout the United States. While the geographical distribution is fairly even, it is not apparent that fairly objective criteria exist and are being applied in the selection of future project areas. Some overall strategy for the selection of future areas would seem to be needed as more new areas are added each year. A basis for this criticism is the observation that in the production of American agricultural products, the total supply is fixed. This poses the question: If one area becomes more efficient in producing a particular product and in fact produces more, does another area lose? If the answer is yes, the more RC&D areas are oriented to agricultural production, the more the effect will be a "wash-out" transaction at the national level. Total economic gains will remain unchanged as one area has proportionately gained and another has proportionately lost.

Nature of the Multiplier

The nature and magnitude of the multiplier is largely unknown for many of the features with which RC&D is concerned. Many questions are being posed regarding the nature of the local multiplier. More research should reduce many of these uncertainties.

(1) Types of investments—We need to determine whether particular types of investments have specific multipliers associated with them and whether peculiarities exist concerning the length of the impact cycles involved. We also need to determine, if possible, the duration effects of any particular expenditures on a particular type of economy.

(2) Type of procedure employed—What is the most efficient way to determine reasonable indices of economic well-being in regional science? Would it be wiser to proceed at the macro level from aggregate data

to arrive at indices, or to proceed from the micro level and derive these estimates from very limited consumer expenditure data?

Leakage

One of the greatest uncertainties encountered in the use of current RC&D methodology is the problem of quantifying "leakage effects" associated with investment and expenditure patterns tied to specific multipliers. The most important factors identified with leakage have been determined to be:

(1) Commuting patterns—The spending patterns assumed for an area so that an economic impact can be imputed depend heavily on accurate delineation of the area in which the labor force works, spends, and lives. Such delineation can be thought of as largely a "data" problem, but it will heavily influence generalizations which may be made about area impacts. As might be imagined, urban and metropolitan areas, especially where more than one State is involved, aggravate data problems. This probably is largely due to the lack of good economic data reported below the State and county level.

(2) Capital flows—Determination of benefits to the community in terms of employment and income derived from the installation of project measures and increased value of the infrastructure is a difficult task. This is made doubly difficult when machines and workers used to construct these installations come from outside the project area. This is frequently the case, and it makes it necessary to determine the net amount that will be added to the community's spending stream. This type of problem also arises in determining the net value contributed to the community by out-of-State absentee landowners who purchase property for retirement, recreation, and/or recreation development.

(3) Underemployment—A special problem is encountered in determining the effects of land treatment and accelerated services on agricultural employment in RC&D project areas. This problem is made particularly acute due to differences in the redundancy or underemployment of the farm labor force. X number of dollars spent on these services will not be readily translatable into Y number of man-years of employment without some determination and adjustment for underemployment on farms.

(4) Recurring employment—One of the most difficult determinations in the translation of expenditures and investments into employment is that of annually recurring employment. How does one distinguish between "one-shot" and continuing employment? While empirically it is possible to estimate man-years of employment for an installation, it is more difficult to identify the permanent addition to the area's recurring employment after the major "one-shot" effects have been dissipated.

CONCLUSIONS

Several important lessons have been learned in the refinement of the methodology used to evaluate impacts of proposed project measures. First, the procedures have encouraged local planners, with the aid of USDA technical personnel, to make a systematic inventory of their community resources. An accurate picture of the importance of planned spending to the local economy could be obtained if the time durations of impacts could be determined for each type of expenditure. Unfortunately, they are presently unavailable. Also, the magnitudes of the multiplier effects are still in question.

Second, ERS methodology has encouraged local planners to think realistically in terms of an appraisal of their economic positions. Third, the methodology has required local planners to specify goals of resource development and community improvement that are then placed in perspective with the means for fulfilling them.

Finally, the methodology has given local planners a realistic blueprint for development and planning for the future. They now possess information that will aid them in spotting "bottlenecks" in their development planning as well as aid them in determining priorities needed in local public investment to stimulate local income and employment.

The RC&D program is undergoing intensive review in current attempts to evaluate its progress to date. The Soil Conservation Service has been in close cooperation with the Economic Research Service in this evaluation process. Four pilot projects in operation since 1964 are being examined to determine their progress to date. The methodology used in evaluating these projects is being refined in an attempt to determine the total impact of all RC&D projects on the economies involved during the lives of the proposed measures.

SECONDARY BENEFIT EVALUATIONS IN FEDERAL RECLAMATION PROGRAMS

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This paper is concerned with benefit appraisals by the U.S. Department of the Interior's Bureau of Reclamation, with special reference to secondary or indirect benefits. Primary emphasis is on present procedures relating to irrigation development. Some discussion of evolvement and perspective is presented as a basis for review of present practices. Certain legislative, administrative, and institutional features basic to secondary benefit analysis in Federal irrigation development are discussed. Passing notes of appraisal and criticism are made, although a critique of the subject is not intended.

GOALS OF FEDERAL IRRIGATION DEVELOPMENT

The Bureau of Reclamation has formally recognized secondary benefits from Federal irrigation development since 1902. The interest-free provisions of Federal reclamation were a major recognition of widespread public benefits from irrigation development.

Support for encouraging settlement on public lands and maximizing settlement opportunities is found in the Reclamation Act of 1902 and in the Reclamation Project Act of 1939. The 160-acre limit on amount of land that an individual may own is a basic element in these purposes. Heavy emphasis is placed also on the phrase "to whomsoever they may accrue," which has its origin in the Flood Control Act of 1936. The dictum of this Act, which originally applied only to the Corps of Engineers and the Department of Agriculture, has been accepted also by the Department of the Interior and the Federal Power Commission as a basis for determining the economic feasibility of Federal projects.

The first Commissioner of Reclamation expressed the objectives of the reclamation program in these words: "The object of the Reclamation Act is not so much to irrigate land as it is to make homes. It is to bring about a condition whereby the land shall be put into the hands of the small owners, whereby the man with a family can get enough land to support that family, to become a good citizen, and to have all the comforts and necessities which rightly belong to an American citizen."

As Quade states, however, "Objectives are not, in fact, agreed upon. The choice, while obstensibly among alternatives, is really among objectives or ends, and non-analytic methods must be used for a final reconciliation of views" (7).[1] And from Wildavsky: "It may be comforting to believe that objectives come to the analyst from on high and can be taken as given, but this easy assumption is all wrong" (9). "For all sorts of good reasons that are not about to change," says Hitch, "official statements of national objectives (or company objectives) tend to be nonexistent or so vague and literary as to be non-operational" (2).

Assuredly, the Bureau of Reclamation has some goals and objectives which serve as a basis for its appraisals of irrigation projects. Agency personnel would argue that these goals are "national" in character. Obviously, some of these goals are not well-defined, nor are the means of their accomplishment. My main general point, however, is that we do not have available stated or generally accepted goals of Federal irrigation or other public resource development. Among other things, I contend that maximizing farm numbers and farming opportunities has been predominant in planning and in economic analysis of irrigation projects. Thus, secondary impacts or goals, if you will, including impacts on local and regional economies, have been paramount in decision making.

The Committee on Economics of Water Resources Development (Western Agricultural Economics Research Council) has given more attention than any other group

[1] Numbers in parentheses refer to Literature Cited, as listed at the end of this paper.

in total, and for a longer period of time, to secondary impacts of water resources development. With the Western setting of the committee, this attention has centered on irrigation development. In its 16 or more reports and "best seller" book, one finds fairly exhaustive treatment of this subject; two reports are devoted entirely to the subject—Report No. 0, "Direct and Indirect Benefits," and Report No. 3, "Benefit-Cost Analysis." Report No. 0 has a paper devoted specifically to practices of Federal agencies in measurement of benefits. It is apparent that with the passing of the last couple of decades, public policy has moved toward increased recognition of local and regional impacts of water resources development in public decision making and cost allocations.

IRRIGATION BENEFITS DEFINED [2]

The Bureau of Reclamation utilizes two major groups of irrigation benefits—one presumably tangible, although not specifically so-called, and the other intangible. This classification apparently is based on a "measurement" criteria. However, some benefits in the category on which dollars are placed are recognized as "judgment estimates."

The group used in benefit-cost ratios comprises three kinds: (1) Primary irrigation benefits; (2) secondary irrigation benefits; and (3) public irrigation benefits. They are defined as follows:

> Primary Irrigation Benefits are the increases in net farm income resulting from the application of project water. The increase in net farm income is derived from differences in project area totals for representative farm budgets with and without the project.
>
> Secondary Irrigation Benefits are increases in the net income of persons other than water users, as a result of the increased flow of agricultural products from the project. The increased income is estimated by the use of factors representing the ratio of a share of profits in later processing to the increased value of farm sales.
>
> Public Irrigation Benefits are effects that contribute to achieving national objectives not included in primary or secondary irrigation benefits. Included among such national objectives are:
>
> > Employment Opportunity. Although long-term price levels reflect relatively high national employment and continued economic growth, some projects may be proposed in areas of economic depression or decline with the national objective of stimulating full employment of labor. For ethnic, sociological, or economic reasons, labor in such areas may not be completely mobile. If limited alternative opportunity due to lack of mobility can be demonstrated for a particular project area throughout the period of analysis, a public benefit due to the project may be claimed for the increased labor earnings of persons other than water users.
> >
> > Economic Growth. Regional development is another well-established national objective of the Reclamation program, and the Department of the Interior has broad responsibilities for the conservation and development of natural resources including water, public land, fish and wildlife, scenic and historic areas, and minerals. Intensified use of such resources promotes economic growth by stimulating other investments, and adds elements of balance and stability in areas where resources are partly or inefficiently employed.
> >
> > As such benefits are not susceptible to evaluation by actual or imputed market prices, a public benefit arbitrarily computed at 5 percent of primary irrigation benefits may be claimed for projects where these effects are substantial.

Intangible benefits, of course, are both primary and secondary. In accordance with Senate Document 97, these benefits are discussed as part of project justification as an aid to decision making (6). They are described as follows by the Bureau of Reclamation:

> Intangible Irrigation Benefits are those improvements in the attainment of national objectives upon which no monetary value can be placed, but which should be taken into account in reaching a decision on project justification. Intangible benefits include:
>
> > Improved Community Facilities and Services.—Adequate appraisal of project plans requires description of social effects as well as economic values. Concentrations of population, productivity, and economic growth generated by project development in sparsely populated areas provide the economic base for improvement in the quality and

[2] Based on statement supplied by the Bureau of Reclamation. The Bureau identifies its benefits as direct, indirect, and public. In this paper, the terms "primary" and "secondary" are substituted for "direct" and "indirect," respectively, whenever the two latter words would ordinarily be used in referring to Bureau projects.

number of such cultural institutions as schools, hospitals, churches, and libraries. Community development also leads to additional provision of public utilities, social services, transportation, and other facilities.

Improved Level of Living.—The national setting assumed for economic analysis includes higher levels of living for an increasing population. Irrigation will contribute to meeting the future demand for a food supply, and is compatible with the national shift in consumption patterns away from a cereal diet toward the types of products more dependent on irrigation, such as livestock, dairy and poultry products, and fresh fruits and vegetables. The increased density of settlement also promotes an increase in household conveniences and amenities, as indicated in studies of rural and urban family living indexes. Improvement in family living is one of the objectives of the Reclamation program. It is made possible by increased net farm income resulting from the project, and by improving the minimum level of living for low-income groups and underdeveloped areas.

Other Intangible Benefits.—Full and definitive description should be provided for any other intangible irrigation benefits that are applicable to particular projects, with emphasis upon qualitative description particularly where such effects have an influence upon formulation of project plans.

PROCEDURES FOR ESTIMATING SECONDARY BENEFITS

The farm budget approach is used by the Bureau of Reclamation for estimating tangible primary and secondary benefits. Marginal effects of enlarged water supplies, farm incomes, expenses, size of farm, cropping patterns, and livestock enterprises are critical elements in the estimations of primary and secondary benefits. Several years ago, and possibly now, the procedures and definitions used by the Bureau of Reclamation to estimate primary benefits and those used to estimate secondary benefits were actually somewhat inconsistent. In particular, public benefits were augmented as farm numbers increased, but smaller farms yielded fewer net primary benefits.

The acreage limitation and family size concept in some instances yield less efficiency and fewer primary benefits. Since the acreage limitation is part of the law, it is argued that national policy recognizes intangible and secondary benefits in this program.

Primary benefits involve a net farm income concept. Secondary benefits are based primarily on changes or differences in gross enterprise incomes between without and with project conditions.

Irrigation

The major element of benefit analyses in water development under the Reclamation Act has been irrigation development. Initially, public land and new farms were prominent in this program. Then, especially as project opportunities diminished on public land, private land became increasingly important. In turn, water development to supplement existing irrigation uses has become increasingly important.

The above changes in program orientation have been vital, especially to the nature and magnitude of estimated secondary impacts associated with Federal reclamation. Settlement opportunities have largely given way to stabilization and improvement of incomes and economies in existing irrigated areas. However, several new land projects are in prospect and most projects include some extension to new lands.

In looking historically at consideration of secondary benefits, we can notice several substantial changes that have occurred in the last few decades. As late as around 1960, secondary benefits reflected both increased profits from handling, processing, and marketing farm products attributable to the project, and increased expenditures for goods and services for farm production inputs and farm family living. The second item, "increased expenditures," is not now explicitly estimated as a secondary benefit.

A second major change relates to the definition of "public benefits." Earlier, these benefits were defined in terms of settlement opportunities; for example, dollars per new farm. As noted above, public benefits are now defined in terms of creation of (1) employment opportunities; for example, in irrigated areas of economic depression and less than full employment; and (2) stimulation of regional economic growth and stability. The benefits originally attributed as "public" now become part of an enlarged definition of primary benefits; that is, the value of family and operator labor, once deducted from net farm income to derive primary benefits and later added as a public benefit, now becomes a primary benefit simply by not making the deduction from "net farm income." These procedures both assume that the alternative opportunity cost for labor in "without project" is zero.

This revised procedure with respect to primary and public benefits overall seems to augment total benefits because a newly defined public benefit is introduced. The revised procedure also should lead to more realistic farm size planning, since farm numbers are now less important in benefit determination.

The tabular material below can be used for illustrative purposes to point out present procedures and apparent recent changes. The example utilizes the settlement-opportunity definition of public benefits and the family living-farm production expenses element of secondary benefits. Categories A and B in the example now are combined to constitute Secondary Benefits; separation is not especially useful. Category C (family living and farm expenditures) is not considered now either.

Shown in the example are estimated aggregate project values for net farm income, gross value of each product sold off the farm, family living allowance less perquisites and alternative labor earnings, and farm

Example of Benefit Computation for an Irrigation Project

Class of benefits	Annual Value	Benefits	Factor
	Dollars	Dollars	
Primary benefits			
Net farm income	1,273,736		
(Alternative earnings)[1]	(385,444)	888,292	
Secondary benefits			
A Small grains	291,097	14,555	.05
Hay and forage	6,293	314	.05
B Wool	434,859	339,189	.78
Meat	1,872,940	206,023	.11
Dairy products	424,885	29,743	.07
Total	3,030,074		
C Family living[2]	329,685	59,343	.18
Farm production expenses[3]	1,869,838	336,571	.18
Total		985,738	
Public benefits			
Settlement	385,444		
		Percent	
Annual equivalent benefits[4]			
Primary	786,137	38	
Secondary	872,378	43	
Public	341,119	16	
Total	1,999,634	97	
Community pasture[5]	57,700	3	
Total project	2,037,800	100	

[1] $1,235 per farm.
[2] Family living allowance less perquisites less $1,235.
[3] Not including livestock purchases–no profit considered by seller.
[4] Adjusted for 10-year period (factor 88.5)–2½ percent interest.
[5] No public benefits.

production expenses. "Alternative labor earnings" are the equivalent of public benefits (settlement opportunities) noted above.

Use of livestock enterprises in these analyses complicates the pricing and income allocation problem, especially in estimating primary benefits. The Department of Agriculture in its Upper Colorado appraisals of primary benefits in the fifties used a crop-budget approach for this purpose. Obviously, crop budgets alone do not meet the needs of secondary benefit estimates as defined by the Bureau of Reclamation.

Secondary Benefits

Assuming that these gross income and expenditure values constitute a reasonable base for estimating secondary benefits—apparently a Bureau of Reclamation Panel of Consultants studying benefits of water-use projects did not raise basic questions on this point—the real imponderable is what factors to apply to these gross values and expenses (4).

It will be noted that magnitudes of factors vary substantially. Some factors used for other products at various times are:

Fruits and vegetables (1)	.74
Sugar beets (1)	.72
Soybeans (1)	.56
Cotton (4)	.83
Poultry products (4)	.06

As noted earlier, secondary benefits are viewed as accruing throughout processing and distribution from farm to consumer. These factors probably are attempts to arrive at a portion of farm value attributed to water that is "added" through the economy because of this "water added" production. Apparently, the factors are computed from U.S. income data for industry groups, but details are not available to the author (1).

The larger factors arise from lengthy and costly processing operations. The Bureau of Reclamation's Panel of Consultants asserted that the imbalance among ratios is "unreasonable"; for example, cotton 83 percent and poultry products 6 percent. At the same time, it is not the high ratio products (and associated projects) for which the greatest economic pressure exists to increase production. Rather, the need is more for meat and dairy products, fruits, and vegetables.

The Panel noted that the current benefit computation procedure is based on average and not marginal returns closely associated with the project activities and that this is the great weakness in the procedure. For example, the marginal secondary benefits of wheat and cotton probably lie largely in export sales and surplus storage—not in average benefits of all products moving into high value uses.

The Panel suggested an arbitrary alternative to reduce the imbalance in factors; namely, to calculate secondary benefits only to a point of first major processing or where a substitute product would be used otherwise; for example, synthetics for cotton and wool, cane for sugar beets.

Public Benefits

Presently used definitions of public benefits lead almost strictly to judgments and arbitrary assignments. The employment opportunity values include considerations of local or national unemployment and immobility of labor in some areas. Actually, USDA recognized the local unemployment and immobility features in the Upper Colorado surveys several years before this procedure was utilized by the Department of the Interior (8).

In the USDA surveys, an assumption of full employment was made on new land projects, and operator and family labor were priced on this basis. On supplemental water projects, variations from full employment of operator and family labor were made, depending on an appraisal of the particular area economy. While these adjustments were arbitrary, they did at least recognize in some areas underemployment and some immobility of labor resources.

The earlier definition of economic growth indicates that a public benefit arbitrarily computed at 5 percent of direct irrigation benefits may be claimed for projects where these effects are substantial. This benefit is based on the premise that stimulation of regional development is a "well-established national objective of the Reclamation program."

Prices

At the present time, the Bureau of Reclamation is applying the current normalized prices developed for the Water Resources Council in April 1966. The Bureau of Reclamation accepted "prices-paid projections" in the 1957 set developed by USDA but did not accept a parity ratio as low as 89 and so used a "prices-received" level

greater than reflected in the 235 index of the 1957 document.

Discounting

In the illustration used earlier, the discounting procedure used by the Department of the Interior is the same for secondary and public benefits as for primary benefits. Usually a 10-year development period on new land projects and a total evaluation period of 100 years are now assumed. The public interest rate is utilized for discounting benefits; many people, of course, argue that a higher rate should be used, especially since privately owned resources are largely involved on the benefit side. In the late 1950's, the Department of Agriculture used 5 percent, compared with Interior's 2½ percent for discounting benefits.

Other Major Water Uses

Federal irrigation projects now frequently include other major purposes, such as power, flood control, municipal and industrial water supplies, and recreation. Benefits from these uses are viewed as primary, or direct, in all instances. Secondary, or indirect, effects undoubtedly exist in connection with development for these purposes. But procedurally, only a single effect viewed as primary evolves.

In the case of power, for example, the benefits are assumed to equal the cost of power obtainable from the most likely alternative source. This restriction places an upper limit for power benefits regardless of the kind of benefit, so the question of primary-secondary is somewhat irrelevant.

Cost Sharing of Secondary Benefits

The Conservancy District is the major explicit application of cost-sharing with respect to secondary benefits from Federal reclamation projects. These Districts are established under State legislation. Provisions are made for ad valorem taxation of all property within the District associated with the use of project water. Funds collected are applied to administration of project water use and for repayment of project costs. The thesis is, of course, that benefits from irrigation projects are widespread throughout the local economy.

The permissible mill levy varies among States. For example, Colorado levies 1 to 1½ mills, Utah and Wyoming levy 1 mill, and New Mexico has no limit specified in the legislation except in years of default, when the levy must not exceed ½ mill.

Basically, delivery of water is generally restricted to the Conservancy District. Technically, the Bureau of Reclamation can sell water to municipalities outside the District but this seldom is done.

Benefit-Cost Ratios

Two ratios are defined in V,A-8 of S.D. 97. They are based on: (1) Primary benefits plus secondary benefits from a national viewpoint, and (2) benefits in (1) plus secondary benefits attributable to projects from a regional, State, or local viewpoint. The Bureau of Reclamation does not distinguish between national and regional secondary benefits. In effect, the Bureau considers three ratios based on: (1) Primary benefits; (2) primary plus estimated secondary; and (3) item (2) plus intangible benefits. Obviously, a specific ratio cannot be calculated for (3).

RELATIVE IMPORTANCE OF SECONDARY BENEFITS IN PROJECT JUSTIFICATION

Secondary benefits estimated on Federal reclamation projects have been relatively large, frequently exceeding in magnitude the estimated direct benefits. Several illustrations are shown below to enhance perspectives on this subject.

Estimates previously recorded in this paper for an unidentified project show discounted secondary and public benefits as 59 percent of total project benefits; secondary benefits amounted to 43 percent of the total.

A February 1958 report by the Department of the Interior on the Colorado River Storage Project, which then included 11 participating irrigation projects, showed average annual benefits from irrigation as follows:

	Dollars	Percent
Total	8,752,000	100
Primary	4,309,000	49
Secondary	2,951,000	34
Public	1,492,000	17

In the above instance, secondary benefits were defined as increased profits to firms handling, processing, and marketing products and to firms supplying goods and services to project farms. Public benefits were increases or improvement of community facilities and services and stabilized local and regional economies.

The Pacific Southwest Water Plan in 1964 showed total benefits of $237 million, of which about 50 percent were attributed to irrigation. This estimate identified an "area development" benefit of $792,000, which is a relatively low percentage of all benefits. This area development benefit was defined as "accruing to temporarily unemployed people in the Southwest through opportunity for employment during construction, and continuing use of some labor for operation and maintenance of project facilities."

The Central Arizona Project Report of 1964 showed:

Primary irrigation benefits	$32.0 million
Secondary irrigation benefits	36.5 million

Young and Martin criticized this magnitude of secondary benefits attributed to irrigation by reference to their input-output study which shows $1 added output generates an additional $1 of income in other sectors of the economy of the State of Arizona but that only the net profit in the added $1 can be considered available "to pay for water" (10).

The above illustrations probably show reasonably well the results—absolute and relative—of Bureau of Reclamation procedures and practices relative to secondary benefits.

Ex Post Studies of Secondary Benefits

Numerous ex ante appraisals have been made of irrigation projects. However, little attention has been given to ex post studies.

The Payette, Idaho, study of secondary benefits sponsored by the Bureau of Reclamation, and published in June 1950, was one of the early studies attracting special attention (3). This study attempted to estimate the "monetary benefits" accruing within a local trade area that were associated with reclaiming sagebrush land by irrigation. The results showed that "for each $1 of net income (direct benefits)" accruing to local farmers, the nonfarm population realized $1.27. "Or, expressed another way: for each $1 of direct benefit, the total benefit realized with the local economy is $2.27." The project included 55,000 acres of irrigated cropland. Primary benefits were estimated for 1946 at $4,635,000 and secondary benefits at $5,891,000. Primary benefits were defined in this study as net farm income, which obviously was not a "net return to water" but rather an amount that might be available to "meet family living expenses, retire capital indebtedness or rent land, and provide for savings." In this study, secondary benefits were likewise defined as total net income for the economy and in no sense was it a net associated with water only.

A more recent study sponsored by the Bureau of Reclamation involved a comparison of two local economies in the Columbia River Basin—one based on irrigated cropland and the other on nonirrigated cropland (5). Comparisons were made on a "per 10,000 acres of cropland" basis. In this study, by Arthur Peterson, all aggregates were substantially greater for the irrigated area. On a per farm and per worker basis, the reverse relation prevailed because the dryland farms were much larger (in terms of capital investment) than the irrigated farms. One stated purpose of this study was to provide a basis for projections of economic growth in areas of the basin where irrigation development remains to be completed. The study does not explicitly presume to conclude that an irrigation economy is preferable to a nonirrigation economy, although some implications for this conclusion might be drawn.

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IV. INPUT-OUTPUT TECHNIQUES

REGIONAL, INTERREGIONAL, AND NATIONAL EFFECTS OF RESOURCE DEVELOPMENT

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Interindustry (input-output) analysis was pioneered by Leontief. His procedures have been adapted to analysis of regions and to expressions of interregional economic relations. The major purposes of this paper are (1) to relate and distinguish regional, interregional, and national interindustry analyses with respect to (a) procedures used, (b) assumptions underlying the procedures, (c) uses, (d) limitations, and (e) ways of improving predictions implied by the results of these analyses; and (2) to briefly assess the applicability of interindustry analysis to planning public investments in natural resource development.

INTERINDUSTRY ANALYSIS

Whether the frame of reference is a region, two or more regions, or the Nation, the basic characteristics of interindustry or input-output analysis are the same. Because of specialization in economic activity by industries, and because production of goods and services for final consumption takes place in stages, the operation of a modern economy is characterized by input-output flows of goods and services among its mutually interrelated industries prior to the stage of final consumption. A description of these interrelations for local, regional, or national economy may be depicted as shown in the table below, where 1, 2, . . . n designate industries, x_{ij}'s denote sales by industry i to industry j (i, j = 1, 2, . . . n), $Y_1, Y_2, \ldots Y_n$ are final demands for products or services of industry 1, 2, . . .n, respectively, and $X_1, X_2, \ldots X_n$ are total outputs of goods and services for industry 1, 2, . . . n, respectively. The x_{ij}'s, Y_i's and X_i's are expressed in dollars in order to convert all of these to a common denominator.

In this schema, the final demands are exogenous—that is, determined outside the system. Final demands include household consumption expenditures, fixed capital formation, net inventory change, exports, and purchases by governments from industries.

Purchases from industry	Sales to Industry				Final Demand	Total output (sales)
	1	2	....	N		
1	x_{11}	x_{12}	....	x_{1n}	Y_1	X_1
2	x_{21}	x_{22}	....	x_{2n}	Y_2	X_2
ı	ı	ı		ı	ı	ı
ı	ı	ı		ı	ı	ı
ı	ı	ı		ı	ı	ı
ı	ı	ı		ı	ı	ı
n	x_{ln}	x_{n2}	....	x_{nn}	Y_n	X_n
Imports						

The table of flow relations can be converted to input-output coefficients by dividing each of the x_{ij}'s by the corresponding total output:

$$a_{11} = \frac{x_{11}}{X_1},\ a_{12} = \frac{x_{12}}{X_1}, \ldots a_{nn} = \frac{x_{nn}}{X_n}$$

A further conversion of the table to interdependence coefficients can be made by an inversion process.[1] The matrix of interdependence coefficients provides estimates of both direct and indirect effects of changes in final demands for products and services of one or more of the industries. The column totals of these coefficients are gross multipliers associated with changes in final demands for products or services of particular industries.

There is not a direct correspondence between direct and indirect components of interdependence coefficients, and primary and secondary effects as usually estimated for resource development projects. The indirect component of these coefficients is one source of local secondary effects. In addition, the direct component of some of the coefficients is a source of local secondary effects. The direct additional purchases by sectors utilizing the services of the projects from other local economic sectors, made in order to utilize these services, are a source of local secondary effects even though these purchases are "first-round" expenditures. The interdependence coefficients reflect gross expenditures (or receipts), whereas primary and secondary effects of projects to local areas supposedly are net monetary and/or nonmonetary effects. Interindustry analysis provides a framework for estimating the local monetary effects of resource development projects. Information sufficient for deriving a matrix of interdependence coefficients is insufficient for estimating the primary and secondary components of the local economic effects of projects. However, interindustry analysis has become an important ingredient in research to estimate local secondary effects.

REGIONAL INTERINDUSTRY ANALYSIS

The economy of the United States is dominated by a hierarchial and spacial structure of cities. Cities, the economic nerve centers for areas of space, spearhead economic development of regions. Although a considerable amount of arbitrariness is involved in defining the geographical boundaries of city-regions, some considerations are (1) purposes of the regional interindustry analysis, (2) nature and availability of data, (3) available research resources, and (4) the spacial characteristics of economic interdependence.

For some purposes, the region may be defined as only the urban area, or the additional open space and smaller central places that are within commuting distance of the major center. When the purpose is to plan developmental policies and programs for lagging areas, the region defined should include the population, physical resources, and cities providing potential for development. When the purpose is to estimate economic effects of watershed or river basin development, account must be taken of both the physical resource region and the affected city-regions in delineating the geographical area for analysis. Regardless of the size of the region selected for study, its boundaries usually must conform to political boundary lines because of the nature and availability of data.

The inexactness and pragmatic nature of criteria for delineating regions preclude any absolute definition of a region. A region is an abstract concept–an analytical frame of references which depends upon the purposes of the investigator.

The early work in regional interindustry analysis entailed dividing the industries within a given geographical area into "basic" and "nonbasic" (or derivative), and estimating an export multiplier as a ratio of employment or income in the basic industries to all industries within the area. Basic industries were those producing products or services for sale outside the region, and nonbasic were those industries producing for markets within the region. There are a number of problems associated with this type of analysis, including (1) the low degree of applicability of this dichotomy of industries, and (2) the misleading implication that economic growth of a region depends solely upon its growth in exports to other regions. Most industries in a region produce for both export and local markets. The economy of a region can expand through either a reduction in its imports or an increase in its exports. However, such problems do not negate the concept of an export multiplier. It is one kind of a regional multiplier that can be obtained from a regional interindustry analysis.

[1] This is $(I-A)^{-1}$, where I is an identify matrix, for example, $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, and A is the matrix of the input-output coefficients $[a_{ij}\text{'s}]$.

Ideally, for an interindustry analysis, we classify the regional economy by sectors (industries) so that each sector produces only one product or service, and this product or service is not produced by any other local sector. Practically, such a classification cannot be obtained. Typically, firms and business establishments produce more than one product or service. Furthermore, even if we could classify the regional economy the ideal way, the interindustry matrix would be unwieldy by sheer weight of numbers of sectors and by the detail of information necessary to implement such a matrix. In practice, we collapse industries into a manageable number of sectors while retaining as much of the distinctiveness of the individual sectors as possible. In so doing, we have a multitude of production processes within each of the sectors, and, correspondingly, conglomerates of production functions within each. We have industry groups rather than industries.

The major distinguishing characteristics of regional interindustry analysis, as contrasted with multiple region or national interindustry analyses, relate to (1) content of the final demands, particularly if the regional economy is considered to be closed; (2) the relation of the multipliers to economic growth; and (3) the limited attention to interregional effects of exogenous forces impinging on the region.

For a closed regional economy, the format of the interregional flows presented earlier is adapted by (1) treating final demand (households and local governments) purchases within the region as one (or more) endogenous industry sector, with sales to this sector(s) as a column(s) and factor payments to this sector(s) as a row(s) in the table, and (2) treating all sales outside the region as final demands, regardless of whether they actually do go to final demands as defined above. In this context, the region's economy is analyzed as a relationship of it to "the rest of the world," as well as in respect to its internal relations in both production and consumption. The interdependence coefficients obtained by the inversion process provide estimates of both direct and indirect effects by sectors per dollar change in final demand for the region's output.

Although the expression of the intersectoral relations is in dollars, with the coefficients expressing trade relations, physical input-output relations are implied. With respect to the production functions, the following is assumed: (1) constant returns to scale, (2) no substitution among inputs, and (3) no joint products. It is further assumed that relations among sectors within the region and between these sectors and the "rest of the world" are affected only by exogenous forces, and these effects are predicted by the interdependence coefficients.

The only valid test of the predictability of a theory or model is an empirical test of its prediction—not the truth or falsity of its underlying assumptions per se. Thus, regardless of the assumptions underlying an interindustry (input-output) model, statements about its reliability for prediction based upon these assumptions must be considered hypotheses until verified or rejected when appealed to the higher tribunal of empirical evidence. It is within this spirit that a few expressions about the assumptions on a theoretical plane are set forth.

If the assumptions about the production functions are false, we need to ask ourselves a number of questions; for example:

(1) What degree of accuracy in the results is acceptable relative to our purposes? Over what time period?

(2) Can we predict changes in the production functions, and take these predictions into account in developing our input-output or trade relations tables?

(3) What characteristics of local economies in terms of kinds of industries, stage of development, competitive position, and other factors affect predictions?

With capital investment a component of final demand, and thus exogenous, regional interindustry analysis excludes from consideration a major variable in growth. What is actually assumed about capital investment is that it is autonomous—that is, it expands or contracts as necessary within the sectors in response to changes in other components of final demand. A more serious problem is the assumption that all sectors can (and will) expand or contract output without change in unit costs. If the sectors already are operating at capacity, the region will not expand output in response to increases in final demand. Also, sectors with fixed assets will not contract production immediately in response to reductions in final demand. Over time, capacity may be increased through capital investment and importation of labor. Also, over time, capacity may be decreased through liquidation of capital assets and outmigration of labor. Such changes in capital and labor cannot be predicted by interindustry analysis.

The assumed stability in trade relations is a serious shortcoming of interindustry analysis. If final demand changes affect trade relations, the interdependence coefficients may poorly predict the actual response of the region to a change in final demand. One prerequisite to stable trade relations is stable price relations. Another prerequisite is the absence of structural change in the region's economy.

Changes in final demand for a region's output may occur through (1) change in levels and structure of national demands for goods and services, or (2) such internal developments as (a) new firms or plants and (b) new or additional resources. The multipliers do not take into account any feed-back effects from other regions arising from adjustments in the region's output. Neither do they take into account any existing trends in the region's economy from forces independent of those taken into account in the model. Also, any agglomeration or accelerator effects are not predicted by the interdependence coefficients.

The static nature of interindustry analysis, as well as possible limitations arising from the departure of the assumptions of the model from reality, suggest that the researcher or planner exercise considerable caution in interpreting the results of this analysis. Inadequate data for developing interindustry accounts necessitates indirect methods of estimation and inclusion of a multitude of judgments to fill gaps in factual knowledge. If empirical tests of the multipliers derived from regional interindustry analysis were made and found to be unreliable, we would not know whether the failure to predict well enough was caused by departures of the assumptions from reality, or inadequacies of the data.

Predictions obtained from interindustry analysis could be improved in two major ways: (1) Improvement in the data used to develop the intersectoral relations, and (2) supplementation of this analysis with other studies. Demographic studies, location of industry studies, economic growth studies, projections, and programing are a few of the means of supplementing regional interindustry analysis.

INTERREGIONAL INTERINDUSTRY ANALYSIS

Interregional interindustry models add a dimension to regional models; namely, each industry's output is allocated to two or more regions. Assuming a national economy is divided into two or more regions, the interregional model takes the form:

$$ {}_{r}X_{i} - \sum_{s=1}^{n} \sum_{j=1}^{m} {}_{rs}x_{ij} = {}_{r}Y_{i} $$

Where ${}_{r}X_{i}$ is total output X of industry i region r, ${}_{rs}x_{ij}$ represents the flow from industry i in region r to industry j in region s, and ${}_{r}Y_{i}$ represents the final demand for the products of industry i in region r.

Technical (or trade) coefficients are:

$$ \frac{{}_{rs}x_{ij}}{{}_{r}X_{i}} = {}_{rs}a_{ij} $$

Which says that the input flows from industry i in region r to industry j in region s are some proportion of total production X of good j in region s. We have added a spatial component to the technical coefficients described earlier. The table of interindustry relations now must include a regional identification to each industry and final demand.

The interregional model may be either open or closed. Households could be considered endogenous to each region; as was described for the regional interindustry analysis. This, then, would be a model closed regionally, and a row and a column would be added to the table for each region. Without considering the households in this way, the model would be open regionally.

The interpretations of interdependence coefficients must account for the added spacial dimension. For the open model, these coefficients can be interpreted as follows: Given any change in final demand for the products or services of any industry, the interdependence coefficients estimate the change in direct and indirect production requirements per dollar change in this final demand for each industry in each region. For the model closed regionally, the interdependence coefficients have the added component of estimating the interacting effects of changes in production and changes in consumption, and the resulting regional location of the change in economic activity. Multipliers obtained from the closed model are difficult to interpret—they have kinship to the Keynesian multiplier but differ in respect to the assumed or implied production and consumption relations. The Keynesian multiplier is based upon marginal propensity to consume (or invest) in the aggregate; the multipliers obtained from interregional interindustry analysis are based upon average relations.

Interregional interindustry analysis requires the added assumption of stable trading patterns among regions. That is, if region h imports half of its wheat from region i and the other half from region j, this trading pattern is assumed to hold for all levels of output. Since interregional interindustry analysis bears the added burden of predicting the impact of a change in national final demand upon each industry in each region, the reliability of this analysis could depend heavily upon the stability of interregional trading patterns.

Prospects for improving the predictability of multipliers derived from interregional interindustry analysis through supplemental studies are less promising than is the case for regional interindustry analysis. The sheer magnitude of the task—say studies of all or several regions simultaneously—may preclude the kind of effort needed to acquire the desired reliability of results. One must ask, Would the gains in reliability be worth the cost? Related questions are: What purposes would be achieved by developing a reliable set of interregional multipliers? Is development of such a set possible? Are there less expensive ways of achieving these purposes?

The procedures for making an interregional interindustry analysis would involve (1) delineation of the regions, (2) development of interindustry accounts for each region, and (3) development of industry accounts of each region with industries of all other regions. The national interindustry (input-output) coefficients would be the best initial data. Other necessary data are scattered, scanty, and expensive to generate.

NATIONAL INTERINDUSTRY ANALYSIS

National interindustry analysis does not differ basically in assumptions or general procedures from this analysis for one or more regions. The interdependence coefficients obtained from a national interindustry analysis express simply the production requirements, by industries, per dollar change in final demands. Such coefficients could not be considered reliable for predicting change in economic activity within the national economy. They fail to take into consideration the major variables affecting investment and consumption decisions, or economic growth, in the national economy. Such omitted variables are monetary and fiscal policies and investment in technology and education. National interindustry coefficients, as predictors, are used only to estimate particular changes in production associated with particular changes in final demands. As such, they are subject to the same kinds of limitations as discussed previously for regional and interregional analysis. However, it may be easier using supplemental studies, to improve upon the predictability of the national coefficients than the greater wealth of information at national than subnational levels.

APPLICABILITY OF INTERINDUSTRY ANALYSIS IN PLANNING NATURAL RESOURCE INVESTMENTS

A simple-minded definition of planning is that it is the process of deciding upon a sequence of future actions to achieve a goal, an objective, or a satisfactory state of affairs. For planning in relation to interindustry analysis, we are concerned with what producers must do to maintain or achieve a given level of future final output; for prediction, we wish to know what they will do in response to changes in levels of demand for final output. What producers must do and what they will choose to do may be closely related; at least the relationship is close enough to necessitate common information requirements.

A variety of uses of interindustry analysis are of value to planners. Some of these uses may be enumerated as follows:

(1) Interindustry analysis provides insight into the structure of regional, interregional, and national economies, and thereby aids in identifying and understanding economic problems associated with:

   (a) Production requirements relating to demand changes;

   (b) factor employment requirements; and

   (c) prospective changes in income levels of people in various economic sectors relating to exogenous factors.

(2) It provides a way of structuring economic knowledge (facts) about regional or national economies;

(3) It aids in determining consistency of various kinds of projections of regional or national economies derived by other methods; and

(4) It provides, directly, some of the forecasts of interest to the planner—that is, short-run forecasts.

Interindustry analysis is one kind of economic analysis. Planning involves not only other kinds of economic analysis, but also analysis relating to other social and technical sciences. It is interdisciplinary. Thus, interindustry analysis is but one in a set of tools used by planners. This is most evident in planning public investments in natural resources.

The period when planning for natural resource investments begins to pay off is necessarily far into the future. And assets created by these investments are reversable only at high costs. Thus, it is of extreme importance that mistakes in planning natural resource investment be minimized.

Because of the long-range context of such planning, multipliers obtained from interindustry analysis have limited usefulness as predictors. These predictors become less reliable with the passage of time because technological and other forces exogenous to the model continuously alter the structural relations underlying the predictions. Furthermore, for a region, or an area of space less than the national economy, multipliers implying major geographical shifts of industry are of limited usefulness because they fail to account for the major forces determining industry locational patterns.

Interindustry (input-output) analysis is one of several techniques for studying regional economies. Supplemental studies are necessary to the planners of natural resources investments. Such studies should emphasize what interindustry analysis excludes by its assumptions.

My major recommendations are that:

(1) More attention be given to interindustry analysis than is currently done by planners of natural resource investment–not for deriving predictions or projections per se out of this analysis, but principally for organizing and checking consistency of estimates obtained by other methods.

(2) Multipliers obtained by interindustry analysis should be viewed as predictions to be improved upon through supplemental studies rather than as a panacea for our problems in making projections or predictions.

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ESTIMATING THE IMPACT OF RESOURCE DEVELOPMENT PROJECTS

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This paper explores the structural interrelationships of a regional economy and the economic implications of alternative changes in the economy. An input-output model has been constructed for a nine-county region in Northwestern Kansas and East Central Colorado. With this model, the impact of the Great Plains Conservation Program (GPCP) on the various sectors of the local economy is assessed.

The analysis also includes a recursive linear programing model of the agricultural sector. Through this model, the impact of irrigation development on agriculture is measured. Irrigation development requires that the agricultural sector purchase additional inputs, processing services, capital inputs, and retail items from other sectors of the economy. The demands for these items stemming from the irrigation development are used as inputs into the input-output model for estimating the direct, indirect, and induced effects of this development on the economy of the area.

THE REGION

The nine-county region consists of Cheyenne, Logan, Rawlins, Sherman, Thomas, and Wallace Counties in Kansas, and Cheyenne, Kit Carson, and Yuma Counties in Colorado. The region contains several towns that serve as trade centers for the surrounding rural communities. While none of the trade centers are large, there are about 10 towns of sufficient size to provide an adequate complement of services to the local people. Since the region contains no large cities, the leakages of trade from this region may be significant. The region was selected to exclude large urban centers and thus is typical of rural America; the economy is based primarily on agriculture.

THE ANALYTICAL MODEL

The nine-county area is described by an 11-sector model as follows:

Sector 1. Primary agriculture—crop enterprises on farms.
Sector 2. Secondary agriculture—livestock enterprises on farms.
Sector 3. Agricultural inputs—includes all purchased inputs for crop and livestock production.
Sector 4. Agricultural processing—farm product marketing, handling, processing, and transportation items.
Sector 5. Other manufacturing—manufacturing activities from raw or intermediate products; also included are mining activities (oil production) of the area.
Sector 6. Retail and service—all retail sales enterprises; service firms such as hotels, motels, auto repair businesses; professional services; and other enterprises of this type.
Sector 7. Households—includes all labor services and is the primary source of demand for products within the region.
Sector 8. Capital inputs—includes only the capital construction (contractors, builders, etc.) in the area.
Sector 9. State and local government.
Sector 10. Federal Government.
Sector 11. Imports or exports.

Building the Model

Two basic approaches were used to construct the transactions table. One is a technique described in the

literature as the "rows-only" method. The matrix is built by obtaining the distribution of sales among sectors in terms of percentages of known total gross sales. These percentages are then applied to the dollar volume of gross sales of each sector to obtain the amount of sales among the various sectors of the economy. Thus, it is assumed that unaccounted-for sales among sectors require intersectoral transactions of the same magnitude as do accounted-for interactions among sectors. Hansen and Tiebout developed this technique in constructing their model of the California economy.

The rows-only technique was used only in part to construct the model. When available, secondary data were also used. The following briefly explains how the two approaches were used together.

Enterprise budgets for the agricultural enterprises of the region were used to construct the columns for the primary and secondary agricultural sectors. The column vectors represent production functions for each sector and reveal the inputs, by sector, necessary to achieve the output level of column total. The complete column for the agricultural inputs sector (sector 3) could not be completed from available secondary data. Particularly lacking was information on lumber, hardware, and motor vehicles. Consequently, the cells in the agricultural input columns were partially filled by the column (production function) approach and the cells were completed by the rows-only technique.

Many firms in sector 3 overlap with those in sector 4, the agricultural processing sector. Annual reports of cooperative firms in the region provided the basis for estimating the transactions with other sectors for both the agricultural inputs and agricultural processing firms.

Data for sector 5, other manufacturing, were particularly scarce. Gross output figures are avilable in the U.S. Census of Manufacturers, but the breakdown of these totals into the relevant sectors is accomplished by the rows-only procedure.

Similarly for sector 6, retail and services, secondary data were available for the secondary agriculture and households sectors only. Other cells in this column had to be estimated via the rows-only method.

Several items in the households sector (7) were available from secondary data. Household purchases from retail and services, capital inputs, and imports sectors are estimated from these sources. The remaining entries in the household columns were completed by the rows-only method.

Data for the capital inputs sector (8) were obtained from secondary sources only for labor hired by construction firms and for government services. The information for columns relating to the two government sectors was taken from national average per capita consumption expenditures. The exports column was completed in part by the column approach. It is assumed that only secondary agriculture, agricultural processing, and other manufactures are exporters from the region.

The Analytical Tables

The transactions table constructed for the nine-county economy is shown below in table 1. Table 2 presents technical coefficients computed from the transactions. One matrix of interdependence coefficients derived from table 2 is shown in table 3. These interdependence coefficients were derived by "opening" the model with respect to households—that is, by excluding the household sector. The coefficients reflect the total dollar production directly and indirectly required from the industry listed across the top of the table for each dollar of delivery to the final demand by the industry listed along the left caption.

In table 4, another matrix of interdependence coefficients represents the "closed" model with respect to households. Households remained in the processing sector during computation of this table. Reasons for presenting the interdependence coefficients for both the open and the closed model will become apparent later.

AN APPLICATION OF THE MODEL

One of the objectives of many resource development programs is not only to strengthen the agricultural sector, but also, indirectly, to aid local communities. Agriculture is the basic industry in many rural areas, and the prosperity of the communities within them depends upon the economic health of the agricultural sector.

The Great Plains Conservation Program (GPCP) applies to a region highly dependent upon agriculture. The nine-county region under study, in particular, has a strong dependence on agriculture. GPCP established contracts that run from 3 to 10 years with farmers for specific land use and conservation measures. The Federal share of costs ranges from 50 to 80 percent and varies for each of the 24 conservation practices included in the program.

Table 1.–Transactions for a nine-county economy in Kansas and Colorado, 1956

Processing sectors	Purchasing sectors											
	1	2	3	4	5	6	7	8	9	10	11	12
	Dollars											
1. Primary agriculture	72	3,459		17,545		1,256				1,738		24,070
2. Secondary agriculture		2,349		4,207		6,263					18,131	30,950
3. Agricultural inputs	7,536	6,686	475	398	38	2,459	1,227	176	495			19,490
4. Agricultural processing	258	1,838				892					30,614	33,602
5. Other manufacturing	152	232	142	117	15	591	368	232			2,101	3,950
6. Retail and services	5,672	4,123	7,862	5,540	665	40,459	36,097	1,732	1,883			104,033
7. Household	5,750	6,745	5,296	1,275	780	26,845		1,206	3,100	3,876		54,873
8. Capital inputs	1,039	793	312	171	48	1,018	405	74	274			4,137
9. Local and State government	1,741	634	409	559	211	2,035	2,977	288				8,855
10. Federal Government	267	370	1,066	2,416	1,655	1,592	8,642	247				16,255
11. Imports	1,583	3,720	3,928	1,374	538	20,623	5,157	182	4,930	2,818		44,853
12. Total gross inputs	24,070	30,950	19,490	33,603	3,950	104,033	54,873	4,137	10,865	8,432	50,864	345,068

Table 2.–Technical coefficients for the nine-county economy

Processing sectors	Purchasing sectors							
	1	2	3	4	5	6	7	8
1. Primary agriculture	.003	.112	0	.522	0	.012	0	0
2. Secondary agriculture	0	.076	0	.125	0	.060	0	0
3. Agricultural inputs	.313	.216	.024	.012	.010	.023	.022	.042
4. Agricultural processing	.011	.059	0	0	0	.009	0	0
5. Other manufacturing	.006	.007	.007	.003	.004	.006	.007	.056
6. Retail and services	.236	.133	.403	.165	.168	.389	.658	.419
7. Households	.239	.218	.272	.037	.197	.258	0	.292
8. Capital inputs	.043	.026	.016	.005	.012	.010	.007	.018

Table 3.–Direct and indirect (interdependence) coefficients, households excluded, for the nine-county economy

Processing sectors	Purchasing sectors						
	1	2	3	4	5	6	8
1. Primary agriculture	1.027	.048	.359	.020	.017	.695	.060
2. Secondary agriculture	.173	1.130	.322	.074	.018	.538	.049
3. Agricultural inputs	.020	.050	1.061	.010	.014	.743	.027
4. Agricultural processing	.566	.187	.255	1.024	.017	.741	.047
5. Other manufacturing	.008	.021	.026	.004	1.007	.314	.017
6. Retail and services	.047	.118	.084	.023	.014	1.763	.025
8. Capital inputs	.021	.054	.083	.011	.064	.802	1.031

Table 4 - Direct and indirect (interdependence) coefficients, households included, for the nine-county economy

Processing sectors	Purchasing sectors 1	2	3	4	5	6	7	8
1. Primary agriculture	1.055	.117	.429	.034	.031	1.726	.870	.081
2. Secondary agriculture	.200	1.198	.391	.087	.032	1.600	.858	.070
3. Agricultural inputs	.045	.112	1.123	.022	.027	1.685	.795	.047
4. Agricultural processing	.590	.248	.316	1.036	.030	1.653	.771	.066
5. Other manufacturing	.023	.058	.063	.011	1.015	.869	.468	.028
6. Retail and services	.072	.183	.149	.036	.028	2.739	.824	.045
7. Households	.049	.124	.125	.025	.026	1.858	1.569	.038
8. Capital inputs	.049	.123	.152	.024	.079	1.843	.879	1.052

.The magnitude of the GPCP in the nine-county area was ascertained from a 33-percent sample of contracts. Contract budgets were used to determine the amount of the expenditure (farmers' and Government's share) to be purchased from each of the sectors of the local economy. The totals for each conservation practice are aggregated to obtain the total input of the GPCP to the local economy. The total input is reflected in changes in the final demand or total outputs for each of the sectors affected. In this way is assessed the impact on the local economy of expenditures to install the practices required in the GPCP.

All the direct changes in total output of the economy resulting from the GPCP are concentrated in three sectors: Sector 3 (agricultural inputs), sector 8 (capital construction), and sector 11 (imports). The total expenditures and Federal payments for conservation practices by sector are shown below.

One may consider that the total expenditures representing both Government payments and individual contributions are direct increases in spending in the economy. However, individual contributions may be substitutions for other types of expenditures; hence, they represent no increase in actual spending in the economy. If such is the case, Government payments would represent direct additions to income of the economy. While the above figures represent direct inputs into the region's econony, the direct and indirect effects of the GPCP on each of the sectors of the economy can be ascertained for tables 3 and 4. Of particular interest are the interdependence coefficients in the rows for the two processing sectors, 3 and 8. The interdependence coefficients in these rows register the direct and indirect effects on the output of the sector listed at the top of the tabulation per dollar change in output of sectors 3 and 8. Thus, the total effect on the retail and services sector (6) from the \$10,524 increase in purchases of agricultural inputs in 1960 is 10,524 x 1.685 (table 4)= \$17,733. The total effect on agriculture (sectors 1 and 2) of the increase in final demand of agricultural inputs (sector 3) is (.045 + .112) x \$10,524 = \$1,652.

Multipliers

From the input-output tables it is possible to construct many types of multipliers. Two multipliers

Year	Sector 3 Total	Sector 3 Federal payment	Sector 8 Total	Sector 8 Federal payment	Sector 11 Total	Sector 11 Federal payment	Total Total	Total Federal payment
	Dollars							
1960	10,524	6,694	29,137	20,250	62	49	39,723	26,993
1961	14,920	9,926	28,464	17,200	134	107	43,518	27,233
1962	28.819	17,562	66,219	38,151	909	727	95,947	56.440
1963	26.693	18,898	128,996	79,712	377	302	156,066	98,912
1964	40,614	26,337	134,367	77,001	266	213	175,247	103,551
1965	42,657	29,059	249,901	145,738	378	302	292,936	175,099
1966	42,262	26,791	123,493	71,900	121	97	165,876	98,788

Table 5.–Income multipliers for the various sectors of the nine-county economy

Sector	Direct income change (1)	Direct and indirect income change (2)	Indirect income change (3)	Type I multiplier (4)	Direct, indirect, and induced income change (5)	Induced income change (6)	Indirect and induced income change (7)	Type II multiplier (8)
1. Primary agriculture	.24	.529	.289	2.20	.870	.341	.630	3.63
2. Secondary agriculture	.22	.512	.292	2.32	.858	.346	.638	3.90
3. Agricultural inputs	.27	.522	.252	1.93	.795	.273	.525	2.94
4. Agricultural processing	.04	.110	.070	2.75	.771	.661	.731	19.27
5. Other manufacturing	.20	.275	.075	1.37	.468	.193	.268	2.34
6. Retail and services	.26	.534	.274	2.05	.824	.290	.564	3.17
8. Capital inputs	.29	.603	.313	2.08	.879	.276	.589	3.03

(1) Column 1 is the households row of table 2.
(2) Column 2 is the sum of (each row entry of table 3) x (the household coefficient of the corresponding column of table 2).
(3) Column 2 minus column 1.
(4) Column 2 divided by column 1.
(5) The household column of table 4.
(6) Column 5 minus column 2.
(7) Column 3 plus column 6.
(8) Column 5 divided by column 1.

that seem especially appropriate for this analysis are the net income multipliers. From the two tables of interdependence coefficients (tables 3 and 4), two types of net income multipliers can be estimated (Type I and Type II).

These net income multipliers, and the details of their calculations, are shown in table 5. The Type I multiplier is sometimes called the "simple income multiplier" since it takes into account only the direct and indirect changes in income resulting from an increase of $1 in the output of the processing sector listed at the left. The Type II multiplier is more complete and accounts for the direct and indirect effects plus the induced changes in net income resulting from increased spending by households. Thus, we see that the net income of the economy will grow by $1.93 per $1 increase in net income of the agricultural inputs sector via the Type I multiplier. The Type II multiplier, which takes into account the chain of intersector reactions in income, output, and consumer expenditures, is $2.94 per $1 increase in net income for the agricultural inputs sector. For sector 8, the Type I multiplier is $2.08 and the Type II multiplier is $3.03.

With these multipliers, the expenditures by sector on conservation practices in the nine-county area can be related to the increase in net income of the region. In 1960, Government payments increased expenditures in sector 3 (agricultural inputs) by $6,694. From column 1 of table 5, we see the direct net income change is $0.27 per $1 increase in expenditures of this sector. Thus, the direct net income change is $6,694 x 0.27 = $1,807. The Type I multiplier is $1.93. Consequently, the direct plus indirect increase in regional net income resulting from expenditures of sector 3 in 1960 is $1,807 x $1.93 = $3,488.

The direct and indirect increases in net income induce still further spending as characterized by the structural relations of the economy. The $6,694 increase in output of sector 3 results in a $6,694 x 0.27 x 2.94 = $5,314 increase in regional net income via the Type II multiplier. When the output of one sector increases, the direct income effects are measured by the increase in payments such as wages, salaries, and operator earnings made in the sector. The indirect effects are the increases in net income in all other sectors that supply the original sector. Induced effects are those that follow when consumers "move up" their consumption functions to increase expenditures on goods and services.

The expenditures by sector on conservation practices in the nine-county region increased household income for 1960-66 as shown below:

Year	Type I multiplier			Type II multiplier		
	Sector 3	Sector 8	Total	Sector 3	Sector 8	Total
	Dollars					
1960	3,488	12,211	15,699	5,314	17,800	23,115
1961	5,171	10,372	15,543	7,881	15,119	23,000
1962	9,150	23,005	32,155	13,944	33,535	47,479
1963	9,846	48,066	57,912	15,005	70,067	85,072
1964	13,722	46,432	60,154	20,912	67,684	88,596
1965	15,140	87,880	103,020	23,073	128,104	151,177
1966	13,958	43,356	57,314	21,272	63,200	84,472

Time Lags

One of the difficulties in interpreting the multiplier effects as derived through an input-output model is to properly specify the speed at which the total effects are spent. That is, does the threefold increase in net income reflected by the Type II multipliers occur within 6 months, 1 year, 3 years, or longer? While this problem may be of utmost importance in certain cases, the matter does not seem to be of major importance here. To assess the impact of a policy such as the GPCP, the total cumulative effect on the economy relative to total costs of the program may be of more importance than the particular time distribution of the benefits. The very concept of conservation does not imply a concern over providing an immediate stimulus to those encouraged to participate.

FURTHER APPLICATIONS OF THE MODEL

The GPCP has not been the only change in this economy in recent years. We have held technology and other changes constant in order to look specifically at the GPCP. Irrigation is one development worthy of attention in the agriculture of the nine-county region. The 1954 Census of Agriculture indicated 19,178 acres under irrigation, whereas the 1964 census revealed 158,862 acres irrigated.

Recursive Programing Model

To assess the impact of irrigation development on the local economy, the input-output model is augmented by a recursive linear programing model (RLP). The impact of irrigation on farmers' incomes, input purchases, and farm output is ascertained through the RLP model.

While irrigation development occurred, the number and size distribution of farms in the region changed. This is important to recognize, since the loss of population from the region caused by declining numbers of farmers may have an effect on the region's economy offsetting irrigation.

The RLP model has three basic characteristics. (1) Starting from a base year (1956), the resource use adjustments permitted on farms are recursively constrained. The output of (or resources used on) a given product in year t are tied to the output level in year t-1. Similarly, output of that product in year t+1 depends upon the output level in year t. By making the linear programing model recursive, one avoids—in part—the assumption of perfect mobility of resources present in conventional linear programing techniques. (2) The development of irrigation expressed in the model corresponds to the region's actual irrigation development. The total amount of land available from irrigated crops in any one year is constrained by the estimate of irrigated acres for that year. (3) The model reflects the declining number of farms, the changing size distribution of farms over time, and the decline of labor in agriculture. Each farm is considered to have one full-time owner-operator. As the number of people employed in agriculture declines, the amount of labor available for hire is reduced accordingly. Changes in the size distribution of farms are handled by considering two size groups of farms—farms with less than 1,000 acres and farms with more than 1,000 acres. As farm numbers decrease and farm sizes increase, the proportion of farms falling in the large size group increases. The population loss from agriculture resulting from both a decline of farm operators and a decline in hired labor available has the potential of reducing the economy's income.

A representative farm was constructed for each size. Total land in farms is about 7.5 million acres in the region. The number of farms of each size when multiplied by the land in each representative farm

Year	Farms with less than 1,000 acres	Farms with more than 1,000 acres	Hired labor available to the large farms [1]	Irrigated land
	Number	Number	Hours	Acres
1960	3,132	2,449	1,748	90,116
1961	3,031	2,453	1,556	107,303
1962	2,930	2,457	1,407	124,489
1963	2,829	2,461	1,237	141,676
1964	2,730	2,465	1,087	158,862
1965	2,629	2,469	938	176,048

[1] Since hired labor available is not sufficient to meet the potential requirement of all farms, all of the hired labor is allocated to the large farm. About 2,500 hours are considered a full-time man equivalent.

aggregates to the total area in each year. The data above reflect the numbers, sizes, and amounts of critical resources available in each year.

The RLP model was specially structured to permit direct consideration of farm adjustments in the input-output model. Accounting rows are defined for the agricultural inputs, agricultural processing, capital inputs, and retail and services sectors. These rows accumulate the derived demands or implied requirements for resources or services supplied by certain sectors. Thus, as changes occur in agriculture resulting from irrigation development, these changes imply changes in demand levels for inputs and the changes are directly reflected for use in the input-output model of the economy.

A word or two is warranted for the retail and services account. Farm incomes are related to this sector by a linear consumption function of the type: $C = 5{,}000 + .2Y$. The retail and services sector requirements, C, are a function of the level of farm income generated, Y. It is assumed that consumption expenditures of $5,000 will occur regardless of the level of income.

Impact of Irrigation

Two programing runs were completed to obtain an estimate of the impact of irrigation on the local economy, net of product and service requirements necessary for conventional agricultural practices. The first run held the amount of irrigated land at zero, and the second run allows irrigated acreage to expand over time in a manner consistent with its development in the region. The difference between the derived demands of products and services of the various sectors between the two runs represents the additional requirements stimulated by irrigation development. Demands for the products and services of the sectors affected are shown in the first tabulation below. The figures represent the

Sector	1960	1961	1962	1963	1964	1965
	1,000 dollars					
(3) Agricultural inputs	1,384	1,609	1,815	1,778	2,374	2,075
(4) Agricultural processing	112	77	18	17	20	23
(6) Retail and services	1,119	1,315	1,482	1,372	1,949	1,469
(8) Capital inputs	520	581	637	614	788	800

Sector	1960	1961	1962	1963	1964	1965
	1,000 dollars					
(3) Agricultural inputs	1,099	1,277	1,441	1,411	1,884	1,647
(4) Agricultural processing	86	59	14	13	15	18
(6) Retail and services	922	1,084	1,221	1,131	1,606	1,211
(8) Capital inputs	457	511	560	540	692	703

net additional expenditures by farmers each year as irrigation expands. These expenditures can be expected to have a multiplier effect on the community's income just as the GPCP had expansive effects. Applying the Type II multiplier coefficients from table 5 to these direct expenditures, we obtain the figures shown at the bottom of page 70. Thus, with the exception of income increases in the agricultural processing services sector, the multiplier effect creates about a threefold increase in net community income. The multiplier for agricultural processing is 19.27. The size of this multiplier is relatively large, since the direct effects are so small. The direct income change is 0.04 (col. 1 of table 5), but the direct, indirect, and induced income change (col. 5 of table 5) is of about the same magnitude as for other sectors. Since the direct income change is so small, changes in expenditures for items in this sector do not have a large effect on the economy.

AN APPRAISAL

The validity or the potential for the techniques used in this analysis to be used in program evaluations can be related to specification of the model and to the assumptions underlying it. The input-output model used was constructed entirely from secondary data sources. Whether such a model reflects the actual structural relationships of the region's economy can, perhaps, only be tested by use of primary data. Apart from this need for primary data, the reasonableness of the technical coefficients may be ascertained by comparisons with those obtained in studies of similar economies elsewhere. Direct comparisons with other studies are difficult because of variations in sector definition.

A major problem in interpreting the multipliers is the nature of the structural dependence within this regional economy. The input-output analysis largely assumes two-way structural dependency or intersectoral complementarity. While it may be true that expanded agricultural output increases requirements for products of agricultural inputs and agricultural processing firms, the reverse may not be true. The structural interdependency in an economy such as the one under study is largely a one-way affair. As with most rural areas, agriculture is the base industry and other industries exist only as the result of direct or indirect service to agriculture. The technical coefficients and multipliers have only a one-way interpretation.

If the region analyzed is a microcosm of a larger area, extrapolation of the results should be possible. For example, if the mix of primary, secondary, and tertiary economic activity in the nine-county region analyzed here is similar to that of the Great Plains, conjecture as to the overall impact of the GPCP is possible. Cursory inspection indicates that such is the case for our region, if we limit the comparison to areas devoid of large metropolitan centers. The findings about the impact of the program to the region under study would probably apply to much of the Plains.

The impact of resource development programs on local communities can be anticipated, at least in part, by the nature of the program. If the program is one (such as the GPCP) that primarily acts to develop physical resources of the area and provides no direct and permanent stimulus to employment, the program's impact may be extremely limited. On the other hand, if the resource development program is one that establishes a new kind of activity (for example, recreation enterprises), the benefits to the community may be much more pronounced. Should the development stimulate population growth as well as per capita income, the likely stimulation of new investment by the retail and service and capital inputs sectors may create large multiplier effects on the economy.

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SECONDARY IMPACTS IN COMPREHENSIVE STUDIES OF THE PACIFIC SOUTHWEST WATER RESOURCE REGIONS

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Secondary impacts–benefits and costs–often weigh heavily on total impacts of development of land and water resources in river basins. Senate Document 97 requires identification of whether secondary benefits are attributable from a national, regional, State, or local viewpoint. When attributable from the national viewpoint, secondary impacts are combined with primary benefits without further qualification. When attributable from a regional, State, or local viewpoint, secondary benefits "shall also be evaluated, when this procedure is considered pertinent, and an additional benefit-cost ratio computed." [1] No further directive is given as to when regional or local secondary impacts should be estimated and included in the benefit-cost ratio and when they should not.

River basin planning studies do not call for specific benefit-cost ratios. The Interagency Comprehensive Framework Studies are preliminary or reconnaissance type investigations. Guidelines for framework studies indicate that "General cost estimates for broad components of the framework plan will be of reconnaissance quality and detail based primarily on experience in the study region. . .Framework studies will reach conclusions as to the urgency of water and related land problems in the subregions and recommend priorities for more detailed studies in the near future (10-15 years) leading to the authorization of an action program for the development of the water and related land resources." [2] While potential sites may be identified, project formulation studies will not be undertaken at any stage of framework planning.

It appears that our work in the Southwest is unique. Correspondence with representatives of the Natural Resource Economics Division reveals that nearly every study group involved in river basin planning is concerned about secondary impacts, but few have done anything about them. A theoretical basis for including and measuring secondary effects is not well developed. The following description of the Colorado economic base study, and the described uses of the results in the Comprehensive Framework Studies, is intended to illustrate potential methods of measuring and including secondary impacts in river basin planning.

THE COLORADO ECONOMIC BASE STUDY

One way of estimating total economic effects is by use of a Leontief type input-output (interindustry) model of the economy. We used this system in a study of the Colorado River Basin sponsored by the Federal Water Pollution Control Administration. The total study is concerned with the primary and secondary effects of quality deterioration, but the major emphasis, particularly in agriculture, is on quantity of water and the problem of salinity.

The study utilizes a regional input-output table for each of the six subbasins of the Colorado River Basin. Several universities have participated in developing the nonagricultural sectors of the subbasin tables. The University of New Mexico and, more recently, the University of Colorado have provided project leaders. The Economic Research Service (ERS), under separate contract, has been responsible for agricultural and forestry sectors of the input-output studies along with cooperative work on industries closely related to agriculture. ERS also has made some special studies of the effect of salinity on cropping patterns, yields, and farm incomes in the Lower Colorado River Basin. These special studies are part of the input to the estimates of salinity damage. An optimum level of water quality

[1] Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, S. Doc. 97, 87th Cong., 2nd Sess., U.S. Government Printing Office, Wash., D.C., p. 6.

[2] Water Resources Council, Guidelines for Framework Studies, Wash., D.C., Oct. 1967.

would be difficult to ascertain, but we anticipate measurement of social costs from alternative deteriorated levels and distribution of gains or losses due to change in water quantity and quality in the several subbasins.

Transactions tables have been prepared for each of the six subbasins in the Colorado for the base year 1960. Conventional input-output manipulations have been accomplished to obtain the most useful coefficients and multipliers. We believe that impacts can only be measured by clearing away the effects of phenomena not directly related to the event for which we desire a measurement. Regular events associated with passage of time are eliminated by projecting "with" and "without" conditions.

In this study, "consistent forecasts" are being derived for each of the six subbasins for 1980 and 2010. Three conditions or assumptions are postulated for each of the projected years.

1. The economy is not constrained by quantity or quality of water except as agricultural land and water development project proposals approximate water availability constraints. Quality of water is assumed to be the 1960 level of salinity. Other quality parameters seem to have little significance.

2. Quantity of water is used as an explicit constraint by accounting for use by sector and in total. Quality of water is assumed at the 1960 level.

3. Quantity and quality of water were both assumed restricting. Quantity was limited by the amount of flow in the river and quality by the amount of salinity caused by use of the water upstream in the river. Quantity requirements were increased by degradation in quality.

For each of the three conditions, we are projecting the economy and measuring the damages using the input-output system. Our work will facilitate evaluation of direct and indirect effects of quality control measures and other impact and development possibilities.

The Input-Output System

Wantrup's classification of types and sources of secondary benefits and suggestions for their measurement were useful in this study.[3/] Also, the methods of forecasting by projecting a transactions table from an input-output matrix as proposed by Miernyk was used.[4/] Two elements, the table of direct and indirect requirements and final demands, are the determinants of total projected output by sector. In matrix notation

$$[I - A]^{-1} \cdot Y = X$$

where $[I - A]^{-1}$ is the Leontief matrix of direct and indirect coefficients; Y is a column vector of final demands; and X is the column vector of sector total outputs. The projection is accomplished by altering one or both of the above two elements from the current values which determine current sector outputs. If technology and trade patterns are assumed constant over time, a new set of final demands for some future time period when used in the above formula will produce a new set of sectoral outputs. Of course, the coefficient matrix alone could be changed. This might be done for analysis of technological change and/or shifts in trade patterns. Both the coefficient matrices and the final demand were varied from base year data in our study, since we were making projections for 1980 and 2010, when both elements were projected to change. Considerable work has been expanded on the question of how coefficients change over time.[5/]

Whether the coefficient matrix alone or the final demands alone or both together are changed, the matrix multiplication provides a "consistent forecast" or projection. Projection is a better word but forecast has come into use in this context. Interdependencies are accounted for among all sectors of the economy. Other methods of projection have the shortcoming that some sectors may require inputs from other sectors in quantities not projected to be available from the supplying industries. Partial forecasts, of course, have some advantages in the detail that can be considered.

The question asked after deriving the projected economy is, Are the resources available sufficient to

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[3/] Ciriacy-Wantrup, S.V., "Economic Analysis of Secondary Benefits in Public Water Resources Development," in Proceedings, Irrigation Economics Conference, Univ. of Alberta, Edmonton, Alberta, Canada, June 10, 1964.

[4/] Miernyk, William H., The Elements of Input-Output Analysis, Random House, New York, 1965.

[5/] Cf. Carter, Anne P., "The Economics of Technological Change," Scientific American, Vol. 214, No. 4, Apr. 1966.

produce these levels of output? Land, labor, water, and capital all are important. Some are immobile, others somewhat more flexible. Land and water resources for agriculture were particularly restrictive in our work. As Hartman has pointed out, the problem is somewhat different from the usual input-output type of study since the exogenous change is in resource supply rather than in final demand.[6] The initial step, then, is to determine the direct output effects of the resource supply restraint and then in turn determine the indirect effects on interdependent sectors through the model.

To demonstrate briefly how our model works, we collapsed the transactions table in one of our subbasins to only three processing sectors, a final demand sector, and final payments sector, as shown below.

From these base year data (1960) with known sales for further processing, sales to final demand, and final payments for each sector, we can learn a good deal about how the economy "works." The even more interesting question is, What does the economy look like if some of the specifications are changed? Particularly, we are interested in the relationship between demands on particular sectors and required output from sectors throughout the economy. The next step is calculation of the table of direct coefficients. This table shows the proportion of its total outlay that each purchasing sector spends in each producing sector.

The direct and indirect coefficients, or coefficients of interdependence, are computed to give one of the two necessary sets of numbers for measuring change. We now have the following numerical estimation of the input-output equation:

$$[I - A]^{-1} \cdot X = Y.$$

$$\begin{bmatrix} 1.121 & .071 & .005 \\ .062 & 1.186 & .039 \\ .440 & .256 & 1.275 \end{bmatrix} \begin{bmatrix} 76{,}200 \\ 92{,}600 \\ 619{,}200 \end{bmatrix} \begin{bmatrix} 95{,}100 \\ 138{,}700 \\ 846{,}700 \end{bmatrix}$$

To illustrate use of the process, we can determine (through the table) agriculture's total output as a check. Multiply the direct and indirect requirements in the agriculture row by the final demand for each sector and sum these totals:

$$1.121\ (76{,}200) + .071\ (92{,}600) + .005\ (619{,}200) = 95{,}100$$

The answers (total output by sector) check with the original transactions table.[7]

Assume that final demands (for 1980, for example) are now projected to be 100,000, 120,000 and 900,000, respectively, for each processing sector. We can now derive a consistent forecast of sector outputs for 1980 in the absence of water quality and quality constraints by inserting the new final demands into the equation $[I - A]^{-1} \cdot Y = X$.

Producing \ Purchasing	Agriculture	Mining and mfg.	Trade, services, utilities, etc.	Final demand	Total gross output
	1,000 dollars				
Agriculture	10,000	7,500	1,400	76,200	95,100
Mining and mfg.	3,500	20,100	22,500	92,600	138,700
Trade, services, utilities, etc.	28,700	21,400	177,400	619,200	846,700
Final payments	52,900	89,700	645,400	549,500	1,337,500
Total gross outlay	95,100	138,700	846,700	1,337,500	2,418,000

[6] Hartman, L. M., "The Input-Output Model and Regional Water Management," Journal of Farm Economics, Vol. 47, No. 5. Dec. 1965, pp. 1583-91.

[7] Some rounding error was assumed away.

In the Colorado study, we changed the direct coefficients to account for expected changes in technology and trade patterns. As an example, assume that we project a new matrix of direct coefficients for 1980. By following steps similar to those listed previously, we can derive the new table of direct and indirect coefficients:

$$[I - A]^{-1} = \begin{matrix} 1.1164 & .0798 & .0053 \\ .0652 & 1.1881 & .0373 \\ .4317 & .2675 & 1.2594 \end{matrix}$$

Using this new projected matrix of direct and indirect requirements and the new projected final demands, we can derive a new consistent forecast for 1980:

$$[I - A]^{-1} \cdot Y = X.$$

1.1164	.0798	.0053	100,000	125,986
.0652	1.1881	.0373	120,000	182,662
.4317	.2675	1.2595	900,000	1,208,730

In this study, we made similar projections for 2010. This completes the "unconstrained" estimates for water alternative (1) as explained earlier where quantity of water was not constrained and water quality was assumed to be at the 1960 level.

Water Coefficients

The next phase of the work is projection and assessment using only water quantity constraints. We have derived water coefficients for each sector. Water coefficients are defined as the gallons of water used (net depletion) in each sector per dollar of total output. Water coefficients derived for 1960 were checked against streamflow records. We know that productivity is increasing in agriculture and that water-use efficiency is increasing. Other changes are occurring in nonagricultural sectors. Therefore, our water-use coefficients for 1980 and 2010 differ from the base year data. Martin and Carter point out that the functional form relating sector outputs with water requirements need not be restricted to a linear homogenous function of degree one.[8/]

Assume in our example that we project 1980 water coefficients to be 3.000, 30, and 3 for the three processing sectors. Multiplying these by projected sector outputs and summing, we project 1980 total water requirements to be 387,064,050,000 gallons, or 1,117,548 acre-feet, neglecting household uses. This demand can be compared with projected supply. If the demand is greater than prospective supply, we must reduce demands on the economy and derive a new "consistent forecast" of the economy at a feasible level of water depletion. Selection of sectors for reduced output can be based on several criteria. One criterion is gallons of water used directly per dollar of output. Still other optimizing or institutional criteria could be used.[9/] Based on whatever criteria are appropriate, the impact of the shortage can be measured. Alternatively, the impact of augmentation, by sectors, can be estimated.

Water Quality Degradation

Turning to the third alternative water situation, it appears that the most significant damages from water quality degradation will be felt in agriculture. But these primary effects in agriculture will also affect other sectors. Some crops are more sensitive than others and the effects are somewhat different. In general, the effect is to shrink the production function in agricultural crop production. Both output-reducing and cost-increasing changes are probable. In our study, a reduction in feasible total gross output is assumed to reduce feasible level of exports so that an adjustment in final demand is required. Cost-increasing changes for items such as fertilizer and drainage are accounted for by changes in the coefficient matrix to reflect increased payments for the required additional costs. Damages resulting from the two types of effects cannot be measured simultaneously in the input-output mechanism, since one decreases sector outputs and the other increases them. The two different kinds of costs must be measured separately, then added together. In each case, the change in total output for all sectors is the amount of damage. Through this method, both direct and indirect effects are measured.

8/ Martin, William E., and Carter, Harold O., "Problems and Applications of a California Interindustry Model," in Proceedings, Western Farm Economics Association, 1960, p. 135.

9/ Lofting, E.M., and McGauhey, P. H., "Economic Evaluation of Water, Pt. III, An Interindustry Analysis of the California Water Economy," Contribution No. 67, Water Resources Center, Berkeley, Univ. of Calif., Jan 1963.

One other main effect of rising salinity not yet mentioned is the need for additional leaching water to purge the crop root zone of the salts applied. Since water is a highly limiting factor of production in the Colorado Basin, use of water for leaching (increasing rates of application) may force cutback in other uses, thus reducing output. There is an important allocation problem in deciding between leaching and other uses of water. Physical constraints such as low permeability in some areas complicate the allocation problem.

A series of projections recognizing the feedback effect between quantity and quality of water completes this phase of our study. The series of alternative conditions and assumptions placed on the models for projections measure the impacts in the time periods under consideration.

PACIFIC SOUTHWEST TYPE I RIVER BASIN SURVEYS

Within the purview of the Water Resources Council's Guidelines [10] and without becoming involved in project formulation studies, the Economic Work Groups in the four regions of the Pacific Southwest Area engaged in interagency comprehensive river basin surveys will estimate the impacts of varying levels of water availability and natural resource developments. Restricting considerations to direct impacts would not adequately meet the challenge that has been given. These studies in the Southwest will utilize and build upon the Colorado Economic Base Study models. Models of the California and Great Basin economies also will be used.

The strong and unique hydrologic, economic, and political relationships in the Pacific Southwest have led to some interesting methods of procedure in the Type I framework planning study. In particular, the whole area, including four major water Resource Regions, has been considered a single Water Resource Region with respect to the limitations on interregional water transfers in the Planning Act of 1965. Since water resources are very limited in some regions, there exists the possibility to solve water resource problems through interregional transfers, along with possible use of water from the Pacific Ocean, if needed. Adequate planning also must consider alternative levels of water and related resource and economic development. This facilitates evaluation of the productivity of alternative levels of investment in the Southwest compared with development or production needed in other regions. Criteria have been developed for study of a broad range of alternatives in each region. The basic problem of our economic studies is to relate projected economic activity to water development and use. We have been given regional allocations of national production which must be translated to levels of resource use. In addition, we must project increments of development of resources and the resultant economic activity. The importance of the secondary impacts of resource development can be ascertained from the data in the following table, which come from the Colorado Economic Base Study and will be used for a subregion in the comprehensive studies. These impacts pertain to the effect on the producing sectors when final demands (essentially exports and consumption) are changed by $1. The effect of a change in resource base which would allow a change in production in certain sectors would be similar. We especially recognize the need to quantify and evaluate the interdependence among heavy water-using industries and the rest of the economy. The relationship among farms and farm-supply firms on the one hand, and farm product processing industries on the other, is but an example.

It is evident that we face some of the same allocation and adjustment problems in our interagency Type I study as were encountered in the economic base study. The input-output technique adapts itself particularly well to measuring the effects of changes in demand on all sectors of the economy, not just the sector producing products for which a demand change is encountered. The effect of a unit increase in final demand can be traced through a typical interindustry table and the effects, both direct and indirect, on interindustry purchases and gross output can be analyzed for any sector. This is the most common type of effect for which a measurement is sought using the input-output technique.

The Pacific Southwest interagency Type I studies will seek answers to a variety of questions, such as the following: What are the interindustry effects of varying supplies of water in a region of the area, or of reallocating water among uses? What will sector gross outputs be, considering only land availability constraints and assuming a great expansion of water supply envisioned under a program of augmentation without regard to source of supply? Or, holding resources development constant, will individual sectors be able to meet final demand projected for a future date? Effects of adjustments in water resource development and/or reallocation may be measured with the model.

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[10] Water Resources Council, op. cit.

Direct requirements and total direct and indirect requirements (output multipliers), combined, per dollar of delivery to final demand, Upper Main Stem Subbasin, Colorado River Basin [1]

Sector	Direct requirements per dollar to/final demand	Total direct and indirect requirements per dollar to/final demand
	Dollars	
1. Range livestock	.247	1.304
2. Feeder livestock	.947	2.302
3. Dairy	.348	1.448
4. Food and field crops	.236	1.273
5. Truck crops	.526	1.606
6. Fruit	.518	1.598
7. Forestry	.069	1.079
8. All other agriculture	.462	1.647
9. Coal	.087	1.101
10. Oil and gas	.232	1.278
11. Uranium	.314	1.424
12. Zinc	.072	1.088
13. All other mining	.088	1.104
14. Food and kindred products	.536	1.756
15. Lumber and wood	.554	1.633
16. Printing and publishing	.078	1.091
17. Fabricated metals	.097	1.110
18. Stone, clay, and glass	.397	1.445
19. All other mfg.	.059	1.075
20. Wholesale trade	.188	1.229
21. Service stations	.147	1.180
22. All other retail	.267	1.313
23. Eating and drinking	.271	1.390
24. Agricultural services	.123	1.147
25. Lodging	.237	1.306
26. All other services	.161	1.196
27. Transportation	.237	1.273
28. Electric energy	.249	1.297
29. Other utilities	.094	1.120
30. Contract construction	.384	1.570
31. Rentals and finance	.069	1.081
Average	.268	1.338

[1] Andersen, Jay, et al., "An Analysis of the Economy of the Upper Main Stem Sub-Basin of the Colorado River Drainage Basin in 1960 With Emphasis on Heavy Water-Using Industries," Univ. of Colo., Boulder, Aug. 1967.

In essence, we are speaking of the following types of possible technological or resource adjustments:

1. Output decreasing–cost decreasing

2. Output increasing–cost decreasing

3. Output decreasing–cost increasing

4. Output increasing–cost increasing

It is evident that some combinations are offsetting. A combined effect of reduced total output with increased cost may have a greater impact upon the economy than a combined effect that is offsetting, such as reduced output with reduced costs.

Increased costs are reflected by higher coefficients in the matrix, or by an increasing portion of output demanded by interindustry transactions and a smaller proportion of output going to final demand. Thus, by considering increases or decreases in total output together with effects of alternative levels of resource development, total impacts may be measured.

CONCLUSIONS

We believe that the relationships among sectors of the economy are important in river basin planning. The interrelationships give rise to secondary impacts from an external influence on the economy. Projections of only the direct effects of a change in demand on change in the production possibilities lack consistency because of the interdependence among sectors. Furthermore, resource requirements for the basin plan would be seriously understated if only direct impacts are calculated. In those studies where the ability to pay for water is based only on the ability of the primary users to pay for it, the payment capacity of local areas is underestimated. If national investment is involved, of course, the direct effects may even be questioned if the products in question are in troublesome oversupply. But, as stated in Senate Document 97, both local and national points of view must be considered.

V. SELECTED OTHER TECHNIQUES OF MEASUREMENT

COMPUTER SIMULATION OF A SOCIOPHYSICAL SYSTEM

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The purposes of this paper are to (1) define computer simulation as a macroeconomic tool of analysis and indicate how it differs from the conventional econometric analytical methods, (2) examine and discuss the features and obstacles associated with simulation as they relate to regional economic systems, and (3) indicate some examples of computer simulation applications to macroeconomic problems.

In this symposium, we are concerned with measuring secondary benefits of public investments in natural resources. By constructing a simulation model of a regional or national economy, we may be able to measure the effects of a public investment in the initial sector of investment, and also trace the induced effects in the related sectors to determine both the primary and secondary effects.

MEANING OF SIMULATION

In a broad context, simulation can refer to all models, either physical or abstract, of a real system, organism, or machine. As economists, our concern is with computer simulation since it represents a numerical technique for conducting experiments which involve certain mathematical and logical models that describe the behavior of an economic system (or some component thereof) over extended periods of time.[1]

Computer simulation has been applied to numerous problems in both the physical and social sciences. It is designed as a sequential or recursive analytical system and hence warrants investigation as a technique for tracing the effects of public investments over time through a selected economy.

Simulation is a laboratory technique for research into the behavior of social systems. It involves the development of abstract models of the structure and behavior of a real system. Such a model enables a researcher to manipulate variables to determine the probable effects on the real system's structure and behavior of changes imposed on the system prior to initiating such changes in the real system itself. Based on alternative model formulations and "runs," the decision-maker is provided information about the potential consequences of alternative courses of action.

Constructing a computer simulation model involves formulation of mathematical or econometric relationships describing the functioning of the economy. The model is built to solve small subsets of relations in a sequential pattern, and, by solving an entire group of separate but related subsets of economic relations, the entire economy is described. When the last subset is analyzed, one time period for the economy has been described, and the computer returns to the first subset of relations and starts the second period of analysis. As the second and succeeding periods are analyzed, variables may be included that were generated in the previous periods. In this way, the model uses feedback information that is generated within the simulation model itself.

Conventional econometric models of regional or national economies usually consist of a complex set of equations that are solved simultaneously for each period. Recursive econometric models that incorporate lagged variables may be constructed to trace the movement of the economy over time. Discrete sets of solutions are thus obtained to yield what might be described as a "jerky" dynamic analysis. Difference equations also have been used to develop dynamic economic growth models. This technique has been confined to highly aggregative problems, with limited application to analysis of regional economies or to problems of specific public investment programs.

[1] This definition has been paraphrased from the one provided by Thomas H. Naylor, et al., in Computer Simulation Techniques, John Wiley & Sons, New York, 1966, p. 3.

PROPERTIES OF COMPUTER SIMULATION MODELS

To gain a perspective of some of the features and limitations of computer simulation as it might be applied in regional economic analysis, we will first briefly review the properties of computer simulation models. Computer simulation models consist of four basic elements: Components, variables, parameters, and relations (6).[2]

Components of an economic model are the units of analysis and depend upon the real system being simulated. If the real system being simulated is a regional economy, the components would be the industry and business sectors important to the region, plus household and government sectors. For example, in a water resource study we would identify and include each of the water-using industries plus all of the industries and businesses that are closely linked to the water-using industries. Whether an industry is being observed for primary or secondary effects depends entirely on which industry is the initial or intended recipient of the public investment.

Variables are used to relate the components and are defined according to the role they play in the simulation process. Variables can be grouped into three categories: Status variables, exogenous variables, and endogenous variables.

Status variables describe the state of the system or one of its components at specified time periods; for example, at the beginning, at selected intermediate periods, or at the end. Status variables interact with exogenous and endogenous variables according to the functional relations of the system. An example of a status variable might be the level of labor force available or amount of output of an industry at a specified time period.

Exogenous variables include inputs, auxiliaries, and time. Both inputs and auxiliaries may be determined either by forces outside the system or by forces under the control of a decision-maker within the economic system. Weather and external policy are two examples of noncontrollable variables, whereas purchased inputs and internal policy are considered controllable variables.

[2] Numbers in parentheses refer to Literature Cited, as listed at the end of this paper.

Endogenous variables are the output variables of the system and are generated from the interaction of status and exogenous variables of the system according to the specified functional relations of the system. In a regional economy model, output variables might include income and employment of industry sectors, population of the region, or total gross regional production. Endogenous variables are examined to determine the primary and secondary effects resulting from an exogenous change to the system, such as a public investment to develop a recreational complex or the establishment of a new industry in the area. The primary effects would be the additional employment and income generated within the industry being established or within the industry in which the public funds are utilized. Correspondingly, the secondary effects would be the employment and income changes in the sectors that are linked to the sectors where primary effects were observed.

Functional relations describe how the variables and components interact to generate the behavior of the system. Relations may take the form of identities or operating characteristics. Operating characteristics are usually mathematical equations relating the system's endogenous, status, and exogenous variables. Examples of operating characteristics are consumption functions, demand functions of an industry, and production functions of a firm.

The parameters of a system specify the rate at which the status and exogenous variables interact. They may be derived from statistical estimating procedures or postulated on a judgmental basis if adequate data are not available for statistical estimates. Obviously, the reliability of a simulation solution will depend to a great extent on the accuracy of the parameters used.

FEATURES OF COMPUTER SIMULATION

Computer simulation consists of structuring a dynamic model that embodies the relevant variables and relationships of the economic sectors to characterize the behavior of a real economic system over time. The equations are solved in a sequential pattern that is similar to the way the economy operates; that is, by a series of separate decisions and actions as information is received and acted upon by individual firms and consumers. Static analysis is a useful tool for analyzing individual decisions and as a pedagogical device for teaching economic principles and theory; however, static analysis is not representative of the environment in

which economic decisions are made. While it may be nice to contemplate a Walrasian system in which decisions and consequences occur simultaneously and the entire system moves toward an equilibrium, we know that this is not the way an economy functions. Simulation, however, does permit formulation of economic models in which actions and information generated in one sector in one time period become part of the variables used in the decision-making process of firms in another sector in a later time period. By analyzing an economy through a series of sets of functional relationships, simulation allows an entire economic system to be analyzed. In this way, a public investment in one sector can be observed to determine the primary effect on employment or income in that sector. Secondary effects in other sectors can also be observed through the functional relations that link the interrelated sectors.

The ability of simulation to utilize "feedback" information in generating a time path of endogenous variables is a major distinguishing characteristic of the process. A feedback loop exists when a component takes its input from a portion of its own output in preceding periods. Many incremental changes to a past action are based on economic decisions similar to those determining the initial action. Simulation is thus more realistic than econometric methods in duplicating the behavior of an economy. Econometric models frequently employ time-lagged variables based on historical observation; however, they seldom use values of endogenous variables in one time period as values for exogenous variables in a later time period.

Another major feature of computer simulation is that it is a nonoptimizing procedure. It is a positive tool of analysis which provides us with "if-then" answers. The nonoptimizing feature is in accord with the requirements that the method of analysis of a complex system be consistent with the operation of the system. A regional economic system is influenced by a wide range of continuously changing forces, so that the economy can be considered in a constant state of disequilibrium. Participants in the economy, however, continually strive to reach a more favorable economic position in an ever-changing environment. Even if optimization is the ultimate goal of participants in an economy, uncertainty surrounds the incremental steps that a decision-maker makes in moving toward an equilibrium position. Computer simulation is a valuable tool for providing the decision-maker with information about the probable consequences of alternative courses of action. He can test his alternatives to determine which one will yield the most satisfactory result, or the largest incremental step toward some larger goal.

The absence of an objective function in a simulation model prevents the analyst from determining when a "best" solution has been found. To some people, this may represent a serious drawback. However, to those who have difficulty specifying an objective function, the simulation model allows experimentation with several alternative investment decisions and permits observation of their likely consequences. After seeing the results, the decision-maker can decide which investment he likes best.

The degree to which a simulation model corresponds to the real system and yields useful information must be determined by the user or decision-maker. If the model is deemed realistic, the decision-maker is confronted with a second evaluation question. He must decide how many runs should be made to adequately evaluate the policy or action decisions that are under examination. Even after a series of runs, the user or decision-maker cannot be certain that an untried alternative may not yield a more desirable solution.

The ability of computer simulation to produce "if-then" answers is of particular significance for estimating primary and secondary effects in a regional economy. Our concern is which alternative level and mix of resource investment will yield the most desirable set of social, economic, and physical consequences. With high-speed computers, numerous runs can be made at nominal cost, and a wide range of alternatives can be considered.

The ability to incorporate demographic and physical factors into a sociophysical model of an economy is another feature of simulation (2) (3) (7). Demographic or physical models can be constructed as subunits of the overall regional model and be treated as an integral part of the model. Formulation of a model in such a manner permits physical, economic, and demographic variables to be considered as endogenous variables whose time paths can be projected and evaluated as a consequence of alternative decisions. This enables a resource development program to be evaluated in terms of noneconomic goals and objectives if relevant to the decision-making process. These noneconomic objectives or effects may be either primary purposes of the resource program or they may be observed as secondary effects resulting as a byproduct from some other specific objective.

LIMITATIONS OF COMPUTER SIMULATION

Computer simulation models of economic behavior do not eliminate all problems associated with mathematical models. And in some respects some problems may be created that are unique to simulation. Because simulation models are tailored to replicate as closely as possible the real system under study, each simulation model is highly specialized. Of course, if two real systems are very similar, a simulation model constructed for one system may be easily adapted to the second with appropriate changes in the parameters and inclusion of unique variables. Designing computer simulation models to fit each real system can be a time-consuming and expensive process. Not only must the variables and functional relationships be carefully considered, but a computer program must be written for each simulation model. Several computer languages have been developed for simulation, such as DYNAMO, SYMSCRIPT, and SIMULATE. However, there is no library program similar to the basic programs that exist for linear programing, regression analysis, and other statistical techniques. Each program for a simulation model must be tailored to that model by using the computing routines within the particular language chosen.

Another limitation to computer simulation is the lack of adequate knowledge with respect to the numerous behavioral linkages among the sectors of an economy. This is not a unique problem to simulation; it is a handicap to any mathematical analysis. In some respects, lack of information about behavioral linkages does not pose as serious a threat to simulation as it does to econometric techniques. Judgment may be used to establish a plausible relationship and test it in a simulation run. Incremental revisions can be made until an acceptable representation of the real system is found.

After reviewing both features and limitations, it appears that computer simulation has the potential of being a useful analytical tool for examining regional economic problems. It is a flexible tool capable of replicating an economy through a dynamic model composed of demographic, economic, and physical variables. The fact that it is a positive analytical device yielding "if-then" answers makes it well-suited as a decision-maker's tool by allowing consequences of alternative decisions to be examined via the simulation model. Consequences generated by the model on the endogenous variables can then be inferred as probable consequences in the real system.

MACROECONOMIC SIMULATION MODELS

The discussion to this point has been entirely on conceptual aspects of simulation and how it might be applied to measure primary and secondary effects in a regional economy. A logical next question might be: Are there any examples of simulation in regional economic analysis? Simulation has been used to study a wide variety of economic problems. Included among these studies are three national and regional economic analyses that were accomplished with the aid of computer simulation. Computer simulation has been used in several macroeconomic analyses to project the consequences of alternative monetary and fiscal policies or regional development policies.

The Brookings Quarterly Econometric Model of the United States is one of the most ambitious simulation models undertaken (1). It consists of more than 250 equations. The principal uses of this model are to forecast the behavior of the U.S. economy and to assist policy makers in their evaluation of alternative monetary and fiscal policy decisions. It also enables economists to obtain a better understanding of the U.S. economic system.

Holland and Gillespie have constructed a simulation model of the Indian economy (4). This study was designed to experiment with a number of alternative policy decisions confronting a government as it attempted to reach the "take-off point" for economic growth. Six sectors were identified. Alternative formulations of policy decisions with respect to investment controls, tariffs, and exchange rates were applied to the simulated economy to determine the effect on the rate of inflation, balance of payments, gross national product, per capita income, and gross real investment in each sector.

A simulation study by Maki, Suttor, and Barnard is of particular significance to this symposium because it simulated a regional economy (5). The Iowa economy was simulated for 1954-74 to determine economic and social consequences of public programs affecting worker productivity and exports of products from the region. The simulation model was formulated around a basic input-output matrix of 18 sectors.

CONCLUSIONS

Computer simulation is a technique by which a set of mathematical equations is specified to describe the operation of an economic system through several time periods. Simulation can include linear, nonlinear, and discontinuous functions, as appropriate, to describe the various operational features and characteristics of the economy. Computer simulation does not substitute for econometric methods but, rather, uses econometric techniques in less complex format to assist in describing the behavior of an economy. Included in the model can be noneconomic considerations, such as demographic features of the population, and physical phenomena, such as weather conditions or water availability. Simulation is a nonoptimizing, positive analytical technique that yields "if-then" answers. Specific objectives or goals need not be specified prior to the operation of the model.

Because computer simulation has the capability of providing "if-then" answers about the behavior of both economic and noneconomic variables of an entire economy over time, it has high potential as an analytical tool for studying economic effects of a regional economy. Alternative resource policies and programs can be analyzed to determine their consequences on the various endogenous variables that are used as indicators of socioeconomic performance of the economy. Both primary and secondary effects can be measured to determine the total impact of a program over the specified time period.

A major drawback of computer simulation for measuring the effects of alternative programs is the need for extensive empirical information about the economy under study. While this is a significant problem to simulation, particularly for small geographic regions, it is a problem equally as serious to other mathematical and econometric techniques that seek to analyze an entire economy. Computer simulation merits more detailed investigation into the specific problem of how a model could be constructed to examine questions of impacts of resource investment and policy.

Computer simulation is a flexible tool of analysis that appears to be well suited for a dynamic analysis of regional economic systems. It enables the estimation of primary and secondary effects of resource investments and resource policy.

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STATISTICAL ANALYSES OF GROWTH AND DEVELOPMENT

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Recommendations for water resource development sometimes are predicated on the premise that growth and development will occur as a result of such investment. Statistical analyses of such relationships are meager; only case studies of water resource development projects are prominent in the literature.

If statistical techniques are to be utilized, some consideration should be given to the alternative techniques–especially a multistatistical approach. If the researcher has acquired sufficient knowledge of the problem in question, has become familiar with the data or facts, and has developed meaningful hypotheses, then logical inferences may follow which lead to predictions of importance. However, statistics can be used to reduce error. An entire family of statistical techniques may be applied in union to the problem under investigation.

The purpose of this paper is to discuss a multivariate, multistatistical approach to analysis of regional growth and development resulting from water resource investment. The paper draws upon Economic Research Service (ERS) experience in planning an analysis of water development alternatives for the North Atlantic Water Resource Region (NAR). The statistical models are discussed as necessary to illustrate the use of the several statistical techniques in their logical sequence. 1/ The discussion of techniques is followed by a summary of data used in the NAR study and conclusions about the multistatistical approach and its ability to enable the researcher to develop meaningful hypotheses.

1/ For the NAR study, all the statistical techniques discussed in this paper, except factor analysis, were applied. Original plans were to apply factor analysis in the sequence discussed; however, interpretation of the regression coefficients and their relationship to the dependent variable exposed the underlying relationship sufficiently well that factor analysis was not needed.

THE MULTISTATISTICAL APPROACH

The multistatistical approach to analysis of regional growth and development is a sequence of interdependent steps in analyzing data, or a sequence in applying different statistical techniques. The first step in this approach is to apply correlation analysis to all the variables listed in the appendix to this paper. This procedure allows us to reduce the total number of variables considered by eliminating those which exhibit similar relationships. The second step is to apply the principal component technique to the measure and independent variables selected in step one. This procedure allows us to remove other variables exhibiting small variances and study only those with large variances. The first principal component of the measure variables, which explains more variation than any other component, becomes an index of growth. This index is made up of a reduced set of measure variables designated by their coefficients or significant loadings. The first principal component of the independent variables, designated in a similar manner, becomes an index of functional relations.

The third step is to regress the reduced set of independent variables against the measure variables expressed as the growth index (dependent variable). Since most of the variation is expressed along a single continuum as a result of the rotation and "fit" of the first principal component, efficiency in the assessment of association is assured in our regression model. Once the coefficients are calculated, they are then interpreted in the usual manner with emphasis given to sign and magnitude of the significant coefficients and their contribution to the value of the dependent variable.

We can expect the presence of intercorrelations which may reduce the validity of the coefficients. We can attempt to isolate those factors generating the intercorrelations or variation in the responses. Therefore, we next apply factor analysis to the selected

independent variables to provide a parsimonious description of the underlying or hidden structure. Once these underlying relationships are exposed, we are able to generate more meaningful hypotheses about functional relations. Also, by analyzing the factor loadings, we can choose those variables that account for the maximum variance and communality of all variances.

We are also interested in the differences in value of the growth index among the reservoirs under study. Discriminant analysis is applied to detect these differences. The growth indices are arrayed in order of magnitude and divided into groups. If it is shown that the selected groups are significantly different, then the derived classification functions will be most useful in separating proposed projects into groups exhibiting similar growth characteristics. The predicted classification is reported in terms of the probability of a project falling within each of the groups. A description of the major methods used in this process follows.

Regression and Correlation Models

In a regression model, it is assumed that all variables are joint, multinormally distributed. We find the conditional distribution a function of our arbitrarily selected dependent variable given the values of the independent variables.[2/] The extent to which changes in the dependent variable are associated with changes in each particular independent variable can be ascertained through several test statistics. In multiregression, the composite relation of the dependent variable to all independent variables together can be determined. However, intercorrelations among the independent variables present problems when attempts are made to measure the separate contributions of the independent variable. Anderson and Brennan both discuss this problem.[3/]

When the investigator is interested in determining one characteristic by a set of other characteristics, multiple regression provides an excellent analytical tool. However, in our problem, the selection of the dependent variable can be highly subjective. When uncertainty of relations exists, it may prove beneficial to explore alternative analytical tools exhibiting more objectivity concerning such critical elements of the study. Or, better yet, alternative techniques may be chosen to make determinations of dependence and independence prior to the application of multiple regression to these relations.

In a correlation model, several variables are considered at random and are treated symmetrically. For a partial correlation analysis, it is necessary to decide which variables are to be correlated and which of the remaining responses must be held constant. Multiple correlation demands that one response be dependent upon some or all of the remaining variates. The independence of two or more responses can be tested by their correlation and is denoted by the multiple correlation coefficient. The correlation model is most useful as a method of reducing the total number of variates to be analyzed. On the one hand, this allows the researcher to investigate many variates, thus reducing the probability of exclusion of contributing relations; while, on the other hand, the variates which exhibit similar relations may be eliminated, thus appealing to parsimony in time and effort.

Principal Component Analysis

Principal component analysis is another statistical technique for exploratory phases of the study when the number of variables under consideration is too large to handle. One way of discarding the irrelevant is to remove those variables exhibiting small variances and study only those with large variances. Principal components are linear combinations of statistical variables that have special properties in terms of variances. These special properties come about through the transformation of the original vector variable to the vector of principal components through a rotation of the coordinate axis to a new coordinate system. This rotation partitions the total variance orthogonally into successively smaller portions and, when these portions are distinct, only one set of coefficient vectors evolves.

In the extreme case, the first principal component would explain all the variation in the multivariate system. In the more usual case, the importance and

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[2/] This relationships can be denoted by:

$$Y_{/X_1X_2} \sim N(\mu_y + B_1(X_1 - \mu_1) + B_2(X_2 - \mu_2))$$

and should not be mistaken for the design model:

$$Y = a + b_1x_1 + b_2x_2 + e$$

which is a linear model with fixed X_is and may be referred to as the "uninteresting" case.

[3/] Anderson, T. S., Introduction to Multivariate Statistical Analysis, John Wiley & Sons, Inc., New York, 1958. Brennan, Jr., Michael J., Preface to Econometrics, Southwestern Publishing Co., Dallas, 1960, p. 342.

usefulness of the component would be measured by the proportion of the total variance attributed to it. For example, in a six-variate system, if 80 percent of the variation could be accounted for by the first principal component, it would appear that almost all the variation could be expressed along a single continuum rather than the six-dimensional space. Not only would this appeal to our sense of parsimony, but the coefficients of the six responses would indicate the relative importance of each original variate in the newly derived component. In calculating the subsequent principal components, which are so constructed as to be linear compounds and orthogonal, the variance of the successive components form to make the total variance of the responses.

Principal component is an objective means of determining the total variance and how it is partitioned. However, in the study of multidependence, we would prefer a technique for explaining the covariances of the responses. Principal component analysis is merely a transformation rather than a measure of a fundamental model for covariance structure. The method poses other shortcomings. The forms of the components are not invariant under changes in the scales of response. No rational criteria exist for deciding when a sufficient proportion of the variances has been accounted for by the principal components. However, a rough "rule of thumb" is that when 75 percent or more of the variance has been explained, it is not fruitful to compute additional principal components. The principal component technique can best be utilized to select those variables of maximum explanatory value.

Factor Analysis

When considering complex phenomena, one procedure is to divide a set of variables into subsets and then test the hypothesis of independence of these subsets. An alternative hypothesis concerns symmetry between or within subsets.

Factor analysis best explains possible interactions or grouping of variables providing similar explanations. Factor analysis begins with two assumptions: (1) That a certain chaotic area is not as chaotic as it appears, and (2) that a situation may be described by some number of functional unities or factors. In technical terms, it is an objective method for selecting dependent variables which can then be considered as the underlying basic structure of the complex system under analysis.

Factor analysis is unique in its ability to pick apart the dependence structure when the responses are symmetric in nature or no a priori patterns of relationship are available.

We attempt to identify those hidden factors generating the dependence or variation in the responses; that is, the observable, or manifest, variates are represented as functions of the smaller number of latent variates. Mathematically, these functions generate the covariance or correlations among the responses and result in a more parsimonious description of the dependent structure. Through the factor model, each response variate will be represented as a linear function of a small number of unobservable common-factors variates and a single latent specific variate. The common factors generate the covariance among the observable responses, while the specific terms contribute only to the variances of their particular responses.

Care must be taken in the selection of variables since the factor model can be oversensitive to the inclusion or exclusion of one or more strategic variables. The goal of variable selection is to choose those variables that may account for at least as much variance as alternative selections, and the communality of all variables selected should be as high as possible.

Discriminant Analysis

Discriminant analysis can be used as a unified approach in solving a research problem involving multivariate comparison of several groups. Such a problem is likely to have as its three phases (1) establishing significant group differences and (2) explaining these differences, and (3) utilizing multvariates for the sample studied in classifying a future individual known to belong to one of the groups represented.

The discriminant function overcomes the problems usually associated with quantitatively specifying a dependent variable. The group assignment procedure is derived from a model of multivariate normal distribution of observations within groups. The model requires the selection of different populations. The selection of the number of populations is a subjective process, but is aided by a test of significance of these populations.

THE DATA BASE

Corps of Engineers, State, and municipal reservoirs constructed between 1950 and 1960 in the Northeastern section of the United States are being analyzed through the multistatistical approach that has been described. Since it is the purpose to separate developmental effects of water resource investment from other economic development influences for the subregion economies under study, those reservoirs constructed within close proximity of metropolitan centers are eliminated from consideration. These were few in number due to the high cost of land in developed areas and the resulting construction of most reservoirs in predominantly rural areas. A bias in data selection of rural community indicators purposely resulted.

Data are obtained on reservoir location by county and State, purpose of the reservoir, gross capacity of the reservoir in acre-feet, year of completion, and the nearest city. Socioeconomic data on the county in which the major portion of the reservoir is situated are obtained for both 1950 and 1960 from county and city data books and the census for all variables suspected of exhibiting relations between water resource investment and growth and development. A partial list of variables considered comprises the appendix to this paper.

One large problem not fully resolved by the use of decennial data to 1960 is the timelag associated with reservoir development. Construction of a reservoir is quite often very disruptive to a community due to movement of households, businesses, and transportation and utility facilities. Community equilibrium is disturbed and time is required before a new equilibrium is effected. This problem was resolved, in part, by observations made in 1950, and previous decennial periods, before development occurred, and in 1960, after water resource investment was made.

CONCLUSIONS

Through the use of the above multistatistical techniques, the investigator may view the facts on hand in several ways and obtain maximum explanatory power from a given set of data in the process. Preconceived ideas about relations are not a necessity. The procedures permit the reduction of the total number of variables by the elimination of those contributing little to explanation of the variance and by identifying the unobservable factors explaining the covariances of the responses.

The techniques assure a high probability of identifying important relationships that are the basis for expressing meaningful hypotheses, determining dependencies, and making reliable predictions. To reiterate, the real world is very complex, and growth and development are a complicated series of events. A systemization and rationalization of facts are made possible through the above combination of techniques.

The procedure as now envisioned is primarily a cross-sectional, statistical approach. Sequences in relations over time can be injected by utilizing ratios of change and/or analyses between two or more points in time (such as 1950 and 1960 or before and after). It would be helpful to have several periods of time since two points are the minimum allowable for the regression model. Also, the statistical techniques discussed are not all inclusive. For example, cluster analysis would be useful in the determination of groups of projects displaying most similar characteristics. What remains is the establishment of experience in the use of the multistatistical approach.

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APPENDIX

PARTIAL LIST OF SOCIOECONOMIC VARIABLES TO BE USED IN THE NORTH ATLANTIC WATER RESOURCES REGION STUDY

Measure

- Δtaxable payroll per capita
- Δmedian income – all families
- Δmedian income – rural families
- Δmedian income – rural farm families
- Δaverage farm income
- Δper capita income
- Δauto, truck, and tractor registrations
- Ratio of bank deposits to aggregate personal income
- Δratio of school enrollment to total population
- Δpercentage of owner-occupied dwellings
- Δtotal property tax
- Δmedian value of owner-occupied housing units
- Δpercentage of dwellings structurally sound, with all plumbing facilities
- Total population change per decade
- Ratio of part-time farms to commercial farms
- Percentage change in total employment
- Δpercentage employed in manufacturing
- Δpercentage employed in agriculture
- Δpercentage employed in white-collar occupations
- Δretail sales per capita
- Δvalue of wholesale trade per capita
- Δvalue of retail trade per capita
- Δvalue of manufactures per capita
- Δvalue added in mining per capita
- Δvalue of land and buildings/farm

Independent

- Value of farm products sold per capita
- Farm wages and salaries
- Other income exceeds farm income
- Lagged per capita income
- Average farm size
- Percentage of commercial farms with sales over $10,000
- Percentage of land area in capability classes I through IV
- Acres irrigated
- Percentage of rural farm population
- Percentage of population over 65 years old
- Percentage of migrants from other counties
- Percentage of nonwhite population
- Median school years completed
- Percentage of population over 21 years who voted in the 1960 presidential election
- Per capita property taxes
- Average size of household
- Percentage change in population density
- Population density
- Number of towns and independent cities
- Nonworker to worker ratio
- Percentage of all workers working outside county
- Public assistance recipients as percentage of population
- Percentage of roads paved
- Project size in acres

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